Traffic Quarterly

TABLE OF CONTENTS, JANUARY 1957

Signs on Police Cars: An Editorial 3
COLONEL ROBERT C. F. GOETZ

The New Highway Program 5
C. D. CURTISS

Factors in Urban Renewal Plans 18
ROBERT E. BARKLEY

Shopper Origins and Destinations 30
WALTER THABIT and NATHALIE LOBE

City's Traffic Efficiency Increased by New Street System in Oklahoma 54
J. H. ROBINSON and GEORGE W. BARTON

Highway Transportation Problems: Organization and Evaluation 64
FLETCHER N. PLATT

The Oakland Signal Formula 83
ERLING HORN

Forecasting Festival Traffic During Jamestown's 350th Anniversary 93
RUDYARD B. GOODE and ROBERT K. TURNER, JR.

Using Creeper Lanes for Trucks On West Virginia Turnpike 114
ELMER K. TIMBY

Highway Development 126
H. A. FLANAKIN

Co-ordinated Traffic Planning 138
WILLIAM R. McGRATH

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Published quarterly by the Eno Foundation at Saugatuck, Conn., issue for January, 1957. Printed in U.S.A. Library of Congress catalog card: 50–1781.

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Signs on Police Cars

DISCUSSIONS of the comparable value of good roads versus bad ones lead to the important subjects of road use, safety and accident rates. They seldom lead to definite, corrective measures. These frequent critical examinations generally fail to propose positive action. Though they invariably include the requirement of a license to drive, the failure to comply with its conditions, or its misuse too often draws no penalties or retractions, though all these precautions are called for—on paper.

Namely, the agencies charged with these functions are licensing, enforcement and the judiciary. The authority and domain of action of these agencies emanate from legislative measures providing a wide range of administrative action. The experience and judgment of those in charge of these offices should lead to improved measures, laws and methods to fully discharge their function.

The lack of uniformity of legislative measures, their various interpretations, and degrees of enforcement have caused confusion and laxity in the minds of those to whom they apply. These are our sixty million drivers.

It is a dismal situation to repeatedly rate our driving efficiency by annual fatalities and their proportions among the states. The horror of it and its ineffectiveness arouse public amazement.

Our driving problem is not one to be readily or easily solved so long as our incoherent efforts prevail. By inertness and perplexities we have warped the attitude of drivers and contributed to their irresponsibility. That is the hall-mark of present-day driving. It is repetitious but worth repeating to declare that the public does not drive as well as it knows how to drive.

Efforts to improve this attitude should not be a sudden reversal of our past apathy—a scourge on the highway. They should be direct and authoritative without ease or pause, and convincing to the public.

We should look sympathetically toward enforcement for it is the police who are nearest to the problem. It is they who need encouragement and greater sustained support. Little can be expected from them without building and upholding their prestige.

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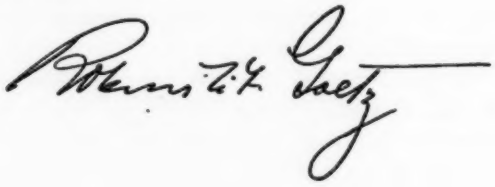
Driving is a national problem. Legal driving in one state can create confusion in other states by its difference from what is or is not legal in those other states.

Constructive ideas to improve public driving should be accompanied by unanimity of method in all states to provide some semblance of national endeavor to meet a national problem. Concerted efforts should aim at improved enforcement, emphasize police function and their responsibility in relation to proper use of the highways. Traffic police rightfully should be provided with specialized training in their duties and authority to gain the support and approbation of the public.

Interchangeable "messages" or "cautions" painted on police cars would appear to serve as a constant authoritative reminder to all drivers, and a contribution toward improved enforcement. This is an untried approach. It may find a profitable place in the effort of public officials to improve our driving.

The procedure would be educational to all drivers. It would emphasize the attributes of good driving and possibly arouse the conscience of the bad driver.



The New Highway Program

C. D. CURTISS

Mr. Curtiss became Commissioner of Public Roads in January, 1955. In this position he directs the work of the Bureau of Public Roads of the Department of Commerce. With a B.S. degree in Engineering and a C.E. degree, he served overseas during World War I in the United States Army as a Captain of Engineers. In 1919, Mr. Curtiss joined the Bureau of Public Roads and was Assistant to the Chief of Bureau for eight years. Subsequently, he was in charge of finance and management activities of the Bureau. In 1943 he was made Deputy Commissioner. As Commissioner of Public Roads, he directs the large program of Federal aid to the states for highway improvement; of physical and economic research in connection with Federal aid; construction of roads in national parks, national forests and other Federal areas; and assistance on highway matters in the Philippine Islands, Turkey, Ethiopia, Liberia, countries of the Pan American Union, and in other foreign countries. Mr. Curtiss was the first Secretary of the Highway Division of the A.S.C.E. and carried on that work for twenty-five years. He was President of the Washington, D. C. section in 1948. Mr. Curtiss is a member of the American Association of State Highway Officials, and of the Highway Research Board of the National Academy of Sciences. Mr. Curtiss was awarded a diploma by the A.S.C.E. for his distinguished service as Secretary of the Highway Division from 1923 to 1947. In 1951 he received the Exceptional Service Gold Medal Award of the Department of Commerce for a major contribution to administration of a Department program.

TRANSPORTATION, the movement of goods and people, has shaped the growth of every civilization. This is especially true of our own country. Many significant milestones remained as this nation spread across the continent.

Today we are vitally concerned with one particular development —the modernization of our highway system. Attention is focused on a single milestone, the Federal-Aid Highway Act of 1956. But even this epoch-making legislation deserves a brief historical setting.

Federal aid began in 1916 when Congress enacted the Federal-Aid Road Act, which laid the foundation for the co-operative Federal-State highway program in existence today. This time-tested pattern,

strengthened and improved over the years, has become an outstanding example of sound Federal-State relations.

Under that program, and still continuing, Federal grants are apportioned according to formulas which give weight to the relative area, population, and rural mail-route mileage in each state. These Federal grants for highway construction must be matched by the states with their own money. The states retain the initiative and prerogative in selecting roads to be improved and the type of improvement. They are responsible for surveys, plans and specifications, for letting contracts, and for supervision of construction, subject to approval by the Bureau of Public Roads. Maintenance of roads built with Federal aid is an obligation of the states.

Legislation since 1916 authorized increasing amounts of money, but the Federal-Aid Road Act has remained the fundamental basis of the co-operative Federal-State highway program.

The Federal Highway Act of 1921 required the state highway departments, in co-operation with the Bureau of Public Roads, to designate a system of principal interstate and intercounty roads, limited to seven percent of the total mileage of rural roads then existing. The use of Federal funds was restricted to this system. Every route in this system was proposed by a state highway department. The Bureau of Public Roads brought the states together in regional groups to arrange the meeting of routes at state lines and thus assure a co-ordinated system of primary roads for the entire country.

Between the two World Wars, a vast Federal-aid network of highways was built. Most of these were two-lane roads. Under the impact of steadily increasing traffic volumes, many sections of this primary system became inadequate, especially those heavily traveled routes serving large cities and industrial areas.

1944 Act Originated Interstate System

The Federal-Aid Act of 1944 took three important steps. It authorized the first specific funds for Federal aid in urban areas. It provided for selection of a Federal-aid secondary system—the farm-to-market roads—and it called upon the states and the Bureau of Public Roads to designate a National System of Interstate Highways,

limited in extent to 40,000 miles and comprising the main routes connecting the important cities and industrial centers of the country.

The need for such a network, built to high standards, had been accumulating for many years. The traffic demands of World War II underscored this need and emphasized the vital role of such highways for defense. By 1947 the states and the Bureau, in consultation with the military, had selected most of the routes which were to make up the Interstate System, and the job was completed in 1955. Although it includes only a little more than one percent of the total rural mileage, this 40,000-mile network—to be increased to 41,000 miles—quite literally serves as an integral part of a grand-scale industrial assembly line. It is as basic to our national defense as it is to our national economy.

But while we had a designated system of main highways and high standards for its ultimate improvement, there was no provision for funds or even the prospect of funds to complete the system in any reasonable period of time. Meanwhile, traffic pressures, traffic accidents, congestion, and delay continued to mount.

The Federal-Aid Highway Act of 1954 directed the Secretary of Commerce to make the first really comprehensive study of our highway needs. As a result, the states were asked to take careful inventory of their highway plant in terms of both today's deficiencies and tomorrow's needs. They were asked to forecast traffic volumes on the Interstate system routes twenty years later, and to estimate the cost of improvements designed to handle such traffic safely and efficiently. They also were asked to estimate the cost of improving all other systems, including the reconstruction of roads now adequate, but which will wear out or become obsolete within the next ten years.

This careful and forward-looking appraisal gave rise to the now familiar figure of $101 billion for highway improvements on all systems in the next decade. This figure was compiled by the Bureau of Public Roads, but the estimates are those of the state highway departments. Theirs was a tremendous task and in fulfilling it they have given the nation a new concept of our highway problem.

While this work was under way other important events took place—events of the greatest significance in bringing about action to meet highway needs. In July 1954, President Eisenhower sent a message to the Governors' Conference calling for "a grand plan for

a properly articulated (highway) system that solves the problem of speedy, safe transcontinental travel; inter-city transportation; access highways and farm-to-market movement; metropolitan area congestion, bottlenecks, and parking."

The message met with strong public support, both from the conference and the public. In September 1954, the President appointed an advisory committee, popularly known as the Clay Committee, to recommend a general plan for dealing with the problem. Preliminary data from the "needs" study by the states and the Bureau were used by the committee in reaching its conclusion.

Reports of the committee and the Bureau, which were submitted to Congress, struck a responsive chord. The findings played a vital part in shaping the Federal-Aid Highway Act of 1956.

Provisions of the 1956 Act

This Act set the stage for the greatest roadbuilding and highway improvement program in all history. Now under way, the huge thirteen- to fifteen-year program for the National System of Interstate and Defense Highways will provide a 41,000-mile network of modern roads and expressways connecting the forty-eight states and linking 209 cities of more than 50,000 population.

The bill authorizes $24.8 billion of Federal funds for the Interstate System. This amount, plus some $2.6 billion contributed by the states, will complete a coast-to-coast system designed to provide for the traffic anticipated in 1975. It will carry millions of vehicles smoothly across the countryside. Traffic will flow into and around large cities over safe, divided highways of four to eight lanes, protected by carefully planned access. Only about 7,000 lightly traveled miles of this system will be two-lane roads and the basic design and right-of-way requirements of these sections must allow for additional divided lanes as traffic increases.

The magnitude of this undertaking, which for the first time envisages the completion of an entire nation-wide highway system, is self-evident.

But the 1956 Act also dealt with other highway problems, apart from the Interstate System. All told, some 755,278 miles of road systems are eligible for Federal aid.

The primary system consists of 216,314 miles of rural highways and 18,593 miles of urban highways, making a total of 234,907 miles. This is the general network of our main highways. Its most important arteries comprise the Interstate System.

The Federal-aid system of secondary or farm-to-market roads is 520,371 miles in extent. Authorized in 1944, it was selected by state highway departments in co-operation with county officials and the Commissioner of Public Roads to best serve the transportation needs of our rural population not served by the primary system.

Federal funds are also provided for road construction in national forests and parks and on Indian reservation roads. In addition, large mileages ranging from truck trails to four-lane divided highways have been built by Public Roads for the Atomic Energy Commission, the Department of Defense, and other agencies.

The 1956 Act provides increased Federal aid for all Federal-aid systems. Prior authorizations—primary, secondary, and urban highways—for the fiscal year 1957 were increased by $125 million to total $825 million. Sums of $850 million and $875 million were authorized for the fiscal years 1958 and 1959, respectively. These amounts are to be divided: 45 percent for the Federal-aid primary system, 30 percent for the secondary, and 25 percent for the urban highways.

These funds will be distributed according to formulas prescribed by law and will be available on the traditional fifty-fifty Federal-State matching basis. A state may transfer up to 20 percent of its share for any of the three systems from one system to another.

For the first time, Alaska is made eligible for Federal aid for highways—primary, secondary, and urban. Only one-third of its land area will be used in applying the regular formula to calculate Alaska's apportionment.

Funds for forest, park, and public lands highways are increased to $103 million for each of the fiscal years 1958 and 1959. This is $22 million more than the annual amount under the 1954 Act.

Other Features of the Interstate System

Since these funds are in addition to those provided for the Interstate System, it is plain that the 1956 Act goes to the heart of our highway problems.

This fact becomes even more evident when we look at those features of the bill which apply to the Interstate System. They are concerned with such important matters as design standards, planned access, advance acquisition of rights-of-way, the inclusion of toll roads and limitation of the weight and width of vehicles.

As we all know, design standards directly affect both highway capacity and the safety and efficiency of traffic movement. Standards adopted for the Interstate System are those formulated by the American Association of State Highway Officials in co-operation with the Bureau of Public Roads. They call for incorporation of all known safety features to provide for safe, relaxed driving and maximum economy of vehicle operation.

The design speed is to be at least 70, 60, and 50 miles per hour for flat, rolling, and mountainous topography, respectively, and 50 miles in urban areas. This does not mean that we expect travel at such speeds—we do not. The figures indicate a wide margin of safety in design.

Traffic lanes are to be at least 12 feet wide, shoulders 10 feet wide, and medians 36 feet wide in rural areas. The roadway will not be narrowed at a bridge unless the bridge is very long, and clearances at underpasses are to be at least eight feet on the right and four and a half feet on the left, with the commonly used minimum vertical clearance of 14 feet.

Perhaps the most important standards are those which deal with access and intersections. Access control is mandatory on all Interstate highways: railroad grade crossings are forbidden; and, except for lightly traveled two-lane roads in sparsely settled western areas, there will be no highway crossings at grade.

In some quarters, *access control* implies an unwelcome restriction. In reality, it means greater freedom. We should think of controlled access as planned access wherein every vehicle entering or leaving the highway will do so on facilities designed for safe and efficient merging with and emerging from through-traffic streams. Here, the safety factor alone is decisive—controlled access reduces accident by about two-thirds.

This is well illustrated by the results of a survey covering more than 2,500 miles of highway: 40 percent without access control, 40 percent with partial control, and 20 percent fully controlled.

The accident rates per hundred million vehicle miles were 408, 204, and 171, respectively, and the corresponding fatality rates 8.0, 9.6, and 2.8.

The higher fatality rate shown for partially controlled highways attests the danger of the unexpected. When building to higher standards where a sense of security encourages greater speeds, we must also provide the safety that full access control affords.

Last year the death toll on our streets and highways reached 38,300. About 1,350,000 people were injured, including more than 100,000 persons who were left with permanent physical impairments. Dollarwise, the National Safety Council estimates the annual loss from traffic accidents at nearly $5 billion.

The Automotive Safety Foundation has estimated that modernization of the Interstate System will save 3,500 lives a year.

Economic Benefits from Planned Access

Safety is a primary consideration, but planned access has many other advantages. Only with such control can we be certain that a highway will retain its capacity to handle traffic. Random access on heavily traveled routes spells obsolescence, congestion, and delay. The inevitable result is to create a need for another highway in still another location. To permit such deterioration on the Interstate System is unthinkable.

Much could be said about the widespread economic benefits which follow in the wake of controlled access roads. No doubt many readers can point to examples which demonstrate that a new route with access control, such as a by-pass, brings widespread economic gains without destroying existing business concerns. And these economic gains are distributed in depth; they are not limited to the strip immediately adjacent to the highway.

Although the famous New York Thruway is not yet completed nor has it been opened to traffic for very long, it is conservatively estimated that already more than $150 million worth of new industrial plants have been erected along this route. These plants are estimated to employ 30,000 persons with an annual payroll exceeding $100 million.

The Boston Metropolitan area with its Route 128, California's

Eastshore Freeway, and many other localities tell a similar story. As the new highway program develops, these patterns of progress and growth will assume nation-wide proportions.

The 1956 Act declares that early completion of the Interstate System is essential to the national interest. To accomplish this, each state highway department should acquire rights-of-way as far in advance of construction as possible and, whenever necessary, enact legislation and appropriate funds to further this objective.

Under certain conditions a state may request the Secretary of Commerce to acquire the rights-of-way for projects on the Interstate System. When the state can subsequently control access, these lands will be turned over to them.

Here are a few of the many advantages to be gained by timely action.

Advance right-of-way acquisition insures a more orderly development of property adjacent to a highway. It keeps to a minimum the number of people who will be adversely affected and it prevents the payment of enhanced prices for property. In most instances this enhancement is created by construction of the highway itself.

California's Revolving Fund

California has set a good example. When real estate development and building activities were encroaching on future highway locations, the state highway department realized the need for early action. In 1952, legislation was enacted which authorized acquiring properties for state highway purposes in cases where prospective developments heralded much higher costs if acquisition was delayed. Ten million dollars was appropriated for this purpose.

Subsequent legislation established a true revolving fund by providing that when properties are purchased with advance acquisition funds they are held until needed for highway construction. At that time the cost is deposited in the fund from moneys assigned for the project, thus making this amount available for re-use in acquiring right-of-way. Under certain conditions, this act also permits the transfer of an additional $20 million to the revolving fund, making a total of $30 million available for advance acquisition.

One California highway official has called this type of program

the greatest single economy that can be made in the highway plant investment.

The new legislation permits the use of Federal funds for advance acquirement of right-of-way provided the state agrees to begin construction within five years.

The fine co-operative spirit and joint accomplishment which characterize Federal-State relations in the highway field have been noted. The 1956 Act enlarges the opportunity for accomplishment. Under its provisions the Bureau of Public Roads with the help of the states and other agencies is called upon to carry out five major studies. Any one of these studies would be a substantial undertaking of itself: taken together they pose a serious challenge not only for the Bureau but for the states as well. Most of the work in the states will fall on the highway planning divisions.

Five Studies by Federal-State Agencies

Taking the studies in order as they appear in the Act, we come first to section 108 (d). This section calls for estimating the cost of completing the Interstate System and must be submitted to Congress by January 1958, only a year away. The importance and urgency of this study are obvious. The results are expected to provide the basis for apportionment of funds for the fiscal years 1960, 1961, and 1962. Re-estimates are then required at intervals through 1968.

The first step is the adoption of standards, which has been done. Next comes the detailed location of the routes of the system, a step going ahead rapidly in the states. Then it is necessary to forecast the traffic volumes, section by section, in 1975. This step calls for the best possible estimate of traffic growth, diversion, and generation, and we expect to work closely with each state through our division and district offices to develop mutually acceptable figures.

Pilot studies have already been started in a number of the states. Finally comes the task of applying the approved standards in making the cost estimates, a step in which we shall expect our engineers to work closely with the state personnel. To permit assembly and review of the material from the states, we are setting a deadline of July 1, 1957, for completing this final step in the field.

Next in order is the study to determine the maximum desirable

sizes and weights of vehicles, described in section 108 (k). This section refers to the AASHO road test, and perhaps implies that the results of that test will answer the question. That test, when completed, will show what pavement structure is required to support specific axle loads applied with known frequency.

To determine what pavement structures will be required on all the Federal-aid systems demands far more comprehensive information than we now have on the magnitudes and frequencies of axle loads to be expected on all systems. And in trying to anticipate what axle loads will be desirable, we must know not only the road cost but also all the costs of vehicle operation for vehicles of various weights and sizes if we are to provide the lowest total cost of highway transport, road and vehicle both included.

Fortunately, the study of vehicle cost being conducted by a committee of the Highway Research Board, staffed by the Bureau, is well along toward completion, aided as many readers know by a number of state highway departments. We do have something over two years in which to complete this study, however.

The third study is closely related to the first. This study, under section 114, is to aid Congress in determining a policy on reimbursement for highways, whether toll or free, constructed between 1947 and 1957 that are included in the Interstate System. This section calls for a determination of the roads that "measure up" to the standards and a study of all factors of "cost, depreciation, participation of Federal funds, and any other items relevant thereto."

It is to be hoped that all states have their road-life studies, long a part of the highway planning program, in good shape and up to date. Calculation of depreciation, of surfacing, structures and other items will be a demanding task. This study, as the first, must be submitted to Congress in January, 1958.

Section 117 describes the fourth study, that of highway safety. This study carries a limitation of $200,000 in expenditures and a completion date twice advanced in conference and set finally as March 1, 1959. It is quite evident that the Congress intends it to be a careful and reasonably deliberate study. We expect it to be complementary to the investigation now being conducted by a Subcommittee of Congress on the same subject, and we plan to use to the extent possible the findings of that group in planning our study.

Two items we definitely hope to include are a pilot study of the real causes of highway accidents and a study of the effect of speed and horsepower on accident causation. In starting this study we are fortunate to have a comprehensive analysis of accident costs nearly completed in Massachusetts, and prospects of early beginning of similar studies in the western region. We should like to see similar work undertaken in this region, for the results will be of much significance to any state in justifying and promoting its highway program.

Finally we come to the fifth and most difficult of all the studies, what we call the "incremental study" outlined in section 210. This study calls for an analysis of the cost of providing highway facilities for different classes of vehicles, and of the benefits derived from highway use by all classes of users. Cost figures must be determined for all Federal-aid systems. In addition we are required to estimate the benefits of highways to other than highway users. And, of course, the purpose is to provide Congress with a basis for determining "equitable" rates of taxation on highway users and other beneficiaries.

To complete this study we shall need, among other things, better highway-use data on all systems, better motor vehicle registration records, and better highway cost data than we now have available in any state. It is without question the most challenging project ever presented to our research division. It will require, and it will surely receive, the assistance of all highway departments. On this study may hinge decisions as to Federal taxation that will have a most far-reaching effect on highway transportation of the future.

Use of Federal-Aid Funds

Federal funds may be used to reimburse the cost of relocating public utility facilities in states which normally pay for such costs. The amount for such use is to be in the same proportion as the Federal funds on a particular system.

On Interstate System projects only, wage scales not less than those prevailing for the same type of work or similar construction in the immediate locality will be established by the Secretary of Labor after consultation with state highway departments.

Interstate funds are available to a state only under certain conditions as to size and weight of vehicles permitted by the state. Maximum weight and width limitations are: 18,000 pounds on a single axle, 32,000 pounds on a tandem axle, an overall gross weight of 73,280 pounds, and a width of 96 inches, or the maximum corresponding weights or widths permitted under state laws in effect July 1, 1956, whichever is greater.

The Interstate System is increased to 41,000 miles. Needless to say, the Bureau will consider the recommendations of the states in the selection of the additional miles with the same care and attention to national interests which featured the original selections.

The 1957 and 1958 funds for the Interstate System have already been apportioned to the states in the manner now provided by law: two-thirds on the basis of population, one-sixth on the basis of area, and one-sixth on the basis of post roads. The 1959 funds will be similarly apportioned, but the remaining Interstate System funds will be apportioned in the ratio that the estimated cost of completing the system in each state bears to the total cost of completing the entire system.

Title II—the Highway Revenue Act of 1956—places this vast new Federal program on a pay-as-you-go basis. It provides for earmarking and putting into a special trust fund revenues estimated to reach $38.5 billion in the sixteen-year period beginning July 1, 1956. About two-thirds of this amount will come from highway taxes that were already in effect when the Act was passed, and one-third will come from new taxes and increases in present rates.

The Federal gasoline and diesel-fuel taxes are increased from two to three cents a gallon with the entire proceeds earmarked for highways. The tax on tires is increased from five to eight cents a pound, and this revenue also goes into the Highway Trust Fund, along with the revenue from tubes, which remains at nine cents a pound.

The trust fund also receives the revenue from a new tax of three cents a pound on camel back recapping-rubber. The tax on trucks, trailers, and buses is increased from the previous 8 percent to 10 percent, and half of this revenue goes to the Highway Trust Fund.

A new use tax on heavy trucks is levied at the rate of $1.50 per thousand pounds for all trucks weighing more than 26,000 pounds.

This is an annual tax and applies to the total weight of any truck or bus with a gross weight over 26,000 pounds. All of this use tax goes to the trust fund.

What do these higher rates mean to the millions of men and women who drive passenger cars? It is estimated that the total cost of the new taxes to the average automobile owner will be less than $9 a year.

As this nation-wide program goes forward, as countless millions of motorists enjoy a new measure of comfort and safety, highway transportation should once again fulfill its early promise—happy motoring!

The Bureau of Public Roads has taken a number of steps to carry out this grand design. Within minutes after President Eisenhower signed the 1956 Act, the additional funds authorized for 1957 were apportioned by the Secretary of Commerce. Apportionment of funds for the fiscal year 1958 followed within a matter of days.

The states have begun to submit lists of projects and early Bureau approval can be expected. Some of the first projects financed by the new funds are now at the construction stage. In late October, the total of programed projects on the Interstate System reached $2.3 million.

A tremendous task lies ahead for the Bureau, for state highway departments and for contractors and suppliers. Looking at past performances and the technical skills now available, there is every reason to believe that the job will be done on schedule.

Factors in Urban Renewal Plans

ROBERT E. BARKLEY

Mr. Barkley is Director of Urban Renewal for the Chattanooga Housing Authority. From 1954 to June of this year, he served as Assistant Director of the City-County Planning Board, Winston-Salem, N. C. Previously, he was a traffic engineer for Wilbur Smith and Associates; in that capacity he prepared engineering reports for projects including the Richmond-Petersburg toll road, highway and traffic improvements in Arlington and Fairfax Counties, Va., and parking garages for Buffalo, N.Y. Mr. Barkley is a member of the American Society of Civil Engineers, the Institute of Traffic Engineers, and the Highway Research Board. He is a registered professional engineer in the State of Ohio.

THERE is no city in the United States that does not have its "slum" area. In some cities, as many as forty percent of all dwelling units are substandard. The presence of these blighted areas, usually in the core of cities, has had a notable effect upon urban growth and urban transportation.

Congress first gave official recognition to the problem of slums in 1937, when it provided funds for the construction of low-rent public housing units. However, progress under this program was relatively slow. During ten years of low-rent public housing in Chattanooga, less than ten percent of all slum dwelling units had been matched by public housing.

Because a similar situation existed in all urban areas, Congress provided an entirely new concept of slum elimination in the Housing Act of 1949. The principles of redevelopment embodied in this act are now generally well known. In 1954, the Housing Act was further enlarged to provide a three-phase attack on slums:

1. *Redevelopment:* Cities can acquire blighted areas, clear the land, revise the street pattern and transportation systems, install needed utilities, and resell the land to private developers. Buildings are then constructed subject to restrictive covenants which embody good planning principles. A successful redevelopment program requires several elements: (a) indisputable evidence of severe blight,

or an obsolete land use pattern; (b) adequate state legislation giving municipalities the right to condemn land and resell it to private developers; (c) proper rehousing for persons relocated from clearance areas; (d) development of site plans (including roadways) by competent technicians, and (e) financing.

2. *Rehabilitation:* Many blighted areas consist of older houses that were once good but have fallen into a state of disrepair. A successful rehabilitation program requires: (a) fundamentally sound residential structures; (b) a good street pattern; (c) adequate residential lot sizes; (d) strict enforcement of a comprehensive housing code, and (e) authority to eliminate badly blighted structures and mixed land uses.

3. *Prevention:* A slum elimination program can have lasting results only if proper measures are taken to prevent the creation of new blight. This requires effective development and administration of the following: (a) a master plan; (b) a zoning ordinance (including parking); (c) building codes; (d) subdivision controls, and (e) a housing code.

Needless to say, all three of these ways of attacking blight must be supported by a dynamic city administration and an enlightened public.

Factors Creating Blight

The most rapid development of American cities took place between 1900 and 1930. Before and during that era, the principal emphasis was making each city bigger, which by some magic would also make it better. This was really the adolescent period in urban growth, and the result was a family of awkward, ugly children. It was primarily because so many mistakes were made that city planning received widespread acceptance.

Because the cities had become ugly, the first emphasis in urban planning was the "city beautiful" movement. Monumental schemes were prepared for civic centers, plazas, and boulevards. Some of these plans were actually carried out, but more often than not they were shelved. In either case, little progress was made toward correcting the fundamental faults of urban life.

The automobile was the next major factor affecting city planning. Between 1930 and 1940, it became apparent that a new sort

of city was forming, molded by the flexibility of the automobile. During this period, the growth of the suburbs began to outstrip the growth of the central city areas. At the same time, fundamental changes in planning administration were taking place. Planning now became a dynamic process trying to adjust itself to the needs of a motorized people.

The flight to the suburbs lessened the demand for land in the central city. Residential streets that were once the pride of every city were left behind in the mass exodus. Large homes were converted to apartments, rooming houses, or just left vacant. Overcrowding and neglect from absentee ownership set in. This suburban flight caused a scattering of our population such as no American or European city has ever experienced.

Mass transit has become less and less economically feasible as route-miles have increased disproportionately to passengers served. As transit service is decreased, the flow of automobiles to the core of the city is increased. More and more traffic uses once-quiet residential streets, and all-day parkers line the curbs of residential areas near the central business district. This in turn lessens the desirability of these residential areas and drives more people to the suburbs. The cycle continues in ever-widening rings from the central business district.

Admittedly, the automobile has not been the only factor in creating blight. There are other elements equally important. While it is a difficult task to categorize all factors that have created slums, such a listing would prove useful in diagnosing one phase of the urban problem.

Environmental Factors

Mixed Land Uses

1. Business in residential areas
2. Residences in business areas
3. Residences in industrial areas

Nuisances

1. Odors
2. Noise
3. Heavy traffic

Business in Residential Area.

House in Business Area.

Overcrowding of Buildings on Land.

Narrow and Poorly Maintained Streets.

FIGURE 1. Environmental Factors Causing Blight.

Overcrowding
1. Of people in buildings
2. Of buildings on land

Poor Community Facilities
1. Old or poorly maintained schools
2. Overcrowded school classrooms
3. Inadequate recreation areas

Housing Factors

Obsolescence
1. Improper maintenance
2. Functional obsolescence
3. No off-street parking

Bad Design
1. Inadequate plumbing facilities
2. Inadequate heating facilities
3. Lack of adequate light and air

Bad Housekeeping

Figure 1 illustrates some of these blight-causing factors as they exist in Chattanooga.

Economic and Social Aspects

Many studies have been made which show that bad housing creates all sorts of negative values, both social and economic. Even the most casual observer can see that slums are no place for decent human beings to live. Examination of the health records of almost any city will show a close correlation between slums and disease. In Washington, D. C. it was found that the highest incidence (measured in cases per 1,000 population) of tuberculosis and syphilis occurred in the most blighted areas.

A spot map of tuberculosis cases occurring in Chattanooga during 1951 showed a general scattering except for a heavy concentration in the two most blighted areas of the city. A similar correlation can be found between slums and crime. The Washington studies mentioned previously also showed that the highest frequency of assault cases and dope addiction occurred in the same blighted areas.

The high frequency of crime and disease in slums imposes disproportionately heavy burdens upon police and health facilities; in addition, demands for other city services are usually heavier than in most residential areas because of higher population densities. On the other hand, tax revenues from blighted areas are low because appraisals reflect the depreciated condition of properties.

Nashville had seventy-two acres of slums which formerly contributed $23,000 in taxes each year. This area is now being redeveloped; major street improvements and other public uses will require thirty-two acres, leaving forty acres for new commercial uses. It is estimated that the remaining forty acres will, when redeveloped, contribute $185,000 in taxes annually.

It has been mentioned that the low-rent public housing program has made relatively little progress in solving the nation's total slum problem. Attempts to step up the size of this program have failed in Congress because of the actions of powerful pressure groups. Any student of the problem recognizes, however, that the current program should be at least tripled in size to properly accommodate families with very low incomes.

Enforcement of good housing codes has proved effective in a number of cities, notably Baltimore and Charlotte. However, a patched-up house does not always eliminate slums, especially where environmental conditions are bad. Another drawback that often occurs is that rentals are substantially increased on a property after repairs are forced upon the owner. The house is then priced out of the range that lower income families can afford.

Planning a Renewal Project

A customary procedure is to begin the preparation of site plans showing revisions in the street pattern, new community facilities, proposed land uses, etc. However, in Chattanooga it was believed that a proposed land use plan should be based on economic data, rather than upon the opinions of a site planner.

Therefore, a market analyst was employed for the following purposes: (a) to study existing economic conditions and project trends for the metropolitan area; (b) determine existing and future demands for various types of land uses in the metropolitan area; (c)

inventory the existing supply of land suitable for various uses; (d) relate supply of land to existing and future demands to determine needs, and (e) investigate competitive advantages of project land in meeting these needs.

The basic procedures used in this analysis are similar to those used in determining the size of a shopping center or the capacity of a parking garage. However, the problems are more complex because so many land use factors are involved—business, commerce, industry, parking, and housing.

After the demand for land uses is established, a site plan is prepared. There is a prevalent misconception that good site plans can be conceived by almost any civil engineer, surveyor, or architect. Site planning is a complex process requiring a high degree of skill and judgment. Any local agency that attempts to undertake a renewal project without the advice of a competent site planner is not assuring that its construction funds will be spent properly. In most projects, the advice of a traffic engineer will also prove invaluable.

Unfortunately, some mistakes have been made in project planning. Some of these mistakes will be cited, not in a critical manner, but to emphasize the need for competent professional advice. In one project, right-of-way for a major highway was obtained through redevelopment. This highway was finally constructed as a four-lane street with additional parking lanes on each side. A narrow median was also included in the cross-section.

This roadway would be adequate for a normal business street; however, this particular highway forms a part of the interregional system. It will not be possible to convert this street to a limited access route, since the abutting land has been sold for ribbon business development. Undoubtedly, if a traffic engineer had been consulted in the planning of this project, provision for limited access would have been incorporated in the design. Instead, additional highway money will have to be spent to bypass this community.

Any traffic engineer could spot other deficiencies in some of the site plans that have been published in project reports. In one case, it was proposed that two major streets should form a "Y" intersection within a redevelopment area. It was easy to visualize the channelization and signal problems that would arise after completion of that project! Other plans have shown street intersections

offset less than several hundred feet apart, and streets intersecting other streets at oblique angles.

Other good planning principles have been violated in some of the site plans. The National Recreation Association established definite standards for parks and playgrounds but these are not always followed. The public has not been made fully aware that recreational facilities are not a luxury, but a vital part of the social health of any community. Part of the responsibility for lack of adequate open spaces in our cities can again be charged to the realtors; they have continually promoted the concept that the highest and best use for a parcel of land is for business or industry. Such may be the case when the individual land owner is considered without regard to the rights of his neighbors.

However, if the rights of our entire urban society are considered, the highest and best use might be for some type of housing that would best fit a master land use plan. The highest and best use of a particular parcel might even be for an agricultural buffer around a city! If real results are to be achieved in making urban areas attractive and healthful places in which to live, many of our basic ideas regarding rights of land use will have to be drastically changed. England, which has a much more mature form of urban development than the United States, is far ahead of us in city planning concepts.

Another disturbing trend observed in some of the renewal land use plans is the provision for ribbon business development along major streets. Most planners know this type of land development has many drawbacks, including the following: (a) it seriously reduces the traffic capacity of a street, and at the same time increases the accident potential; (b) it does not permit effective groupings of buildings, nor permit proper provision for parking, pedestrian circulation, and truck servicing; (c) this lack of co-ordination in developing a ribbon of business structures causes a hodge-podge affair that eventually becomes a commercial slum; and (d) property abutting this type of development in the rear normally becomes blighted, since it is difficult to provide and maintain good buffer areas.

Yet, despite these serious objections to ribbon commercial development, a number of projects have incorporated this feature in their plans. It is not inconceivable that in so doing, a site planner is

tearing down a residential slum and substituting a future commercial slum in its place.

Many cities are incorporating expressway plans into their urban renewal projects. This is an excellent idea, since it permits good co-ordination between land use and highway location. Very often, the expressway can be routed so as to form a buffer between two conflicting types of land uses. It is normally desirable to let the redevelopment authority be responsible for acquiring the right-of-way for an expressway project. This is because many state highway departments do not have the right to acquire any more land than is actually needed for construction. Consequently, severance damages must often be paid on that part of a parcel that is not acquired. On the other hand, the redevelopment authority can negotiate for the entire parcel; the savings in severance damages very often equal the cost of the extra land acquired.

Relocation Studies

Any renewal project requires a careful analysis of population characteristics within the affected area. Proper planning requires information on number of families and persons, age distribution of population, income characteristics, monthly rents, and other related factors. Most of these data are available from the 1950 block statistics. However, most cities have experienced rather marked changes in rent and income characteristics since 1950 and a resurvey of the project area is generally advisable.

A sample survey will be adequate in the preliminary planning stages. The size of the sample selected will depend upon the number of dwelling units within the area and the accuracy of results desired. The number of dwelling units within the area can be obtained from census figures, Sanborn maps, land-use studies, and the city directory. The reliability of the sample results is measured by the "confidence interval." A 95 percent confidence interval insures that the chances are nineteen out of twenty that the percentages derived from a sample would not deviate from the true percentages by more than predetermined amounts. Normally, a 3 percent to 5 percent deviation can be tolerated in the preliminary planning stages. The chances are two out of three that the maximum deviations would be

one and a half to two and a half percent. Table I gives the size of samples required for a 95 percent confidence interval with 3 percent, 4 percent and 5 percent maximum deviations.

Table I

SAMPLE SIZES FOR HOUSING SURVEYS[1]
(95 percent Confidence Interval)

Number of Dwelling Units	*Sample Size for a Maximum Deviation of*		
	3 percent	*4 percent*	*5 percent*
500	500	500	222
1000	1000	385	286
1500	638	441	316
2000	714	476	333
2500	769	500	345
3000	811	517	353
3500	843	530	359
4000	870	541	364

Samples should be selected on a random basis. Methods developed by the Bureau of Census are usually satisfactory.

The presentation of data concerning tenant characteristics is an important task. To make relocation problems clear to the layman, generous use should be made of graphs and bar charts. In Chattanooga, data concerning rents and incomes were plotted as frequency distribution curves. These graphs proved very useful in studying housing characteristics. For example, if it is assumed that 20 percent of a family's income can be spent on rent, the market for housing at any rent level can be obtained from the income distribution curve.

Other tabulations normally prepared for a renewal program include public housing eligibility by family size, and age distribution of the population. The latter tabulation is especially helpful in determining recreational and school requirements for relocated tenants. One other useful correlation is family size related to income.

Housing Standards

Practically every urban renewal or expressway program involves the removal of dwelling units. In the case of urban renewal projects,

[1] "A Method for Employing Sampling Techniques in Housing Surveys," New York State Division of Housing, September, 1948.

the Federal government demands that relocated families be placed in decent, sanitary, and safe dwelling units. Unfortunately, this same requirement has not been imposed on highway projects. It would seem that local governments have a moral responsibility in this matter that they have not assumed because of administrative complications.

One of the initial difficulties facing any administrator responsible for tenant relocation is establishing standards for decent, safe and sanitary housing. In some cases, cities have adequate housing codes that can be used to evaluate present conditions. Where desirable standards do not exist, the administrator can find help from publications of the Urban Renewal Administration[2] and the American Public Health Association.[3]

Any comprehensive standards will include provisions for safe structural conditions, good maintenance, adequate heating and wiring, proper plumbing facilities for each family, and limits upon occupancy. The Federal government, through its workable program, is offering much help to cities in developing proper housing codes.

A good housing code will also serve as a basis for rehabilitation standards in renewal areas. However, the code must be supplemented and expanded to include minimum criteria for environmental conditions. Standards for desirable environment are not as well established as are standards for housing conditions. It is obvious that provision should be made for proper street access, removal of unsightly outbuildings, and yard maintenance. Also, minimum rehabilitation standards should conform with applicable provisions of local zoning ordinances. Each city must develop its own environmental standards. The assistance of the local office of the Federal Housing Administration will prove invaluable.

The Workable Program

An urban renewal project will not be effective unless it is coordinated with city-wide plans for the prevention of blight. The Housing Act of 1954, as amended, provides that cities carrying out

2 "Provisions of Housing Codes In Various American Cities," Housing and Home Finance Agency, Urban Renewal Administration, 1956.

3 "An Appraisal Method for Measuring the Quality of Housing," Parts I, II, III, American Public Health Association, 1945.

urban renewal projects must also have a workable program made up of the following components: (a) a land use plan; (b) a major street plan; (c) a plan for schools, parks, and other public properties; (d) a capital improvements program; (e) zoning ordinance and map; (f) regulations governing the subdivision of land; (g) a housing code, and (h) building codes. In addition, the local governmental agency must furnish evidence that proper administrative procedures exist, and that adequate personnel are available, to carry out these various components of a workable program.

Because the availability of federal funds for urban renewal projects is contingent upon a workable program, many cities are creating full-time planning staffs where none have existed before. This has been the case in Chattanooga; although in past years the city had employed several consultants to prepare planning reports, it did not have any staff to effectuate the recommendations made in these reports. The desire of Chattanooga to undertake an urban renewal project has also compelled the city to set up a planning staff. This staff has compiled many data regarding the city that formerly were not available. Other cities have had similar experiences. Therefore, it can be said that the net result of the workable program has been to extend and broaden planning concepts throughout the United States.

The chief deficiency of the existing workable program is that it is not broad enough in scope. For example, a master plan of land use does not have to be supported by an economic analysis. Similarly, a major street plan does not have to be substantiated by an origin-destination analysis projected to some future year.

The workable program, besides being limited in the amount of statistical data required to support a master plan, is also limited in areal coverage. The most rapid growth in practically every city is occurring outside of the city limits. In the decade from 1940 to 1950, the central part of Chattanooga remained fairly stable in population, while the fringe areas increased about 38 percent. The urban fringe of Nashville increased 64 percent while the central city increased only 4 percent.

Other cities have shown even more spectacular growths. Much of this growth in our urban fringe areas has taken place without the benefit of any planning. Master plans, zoning administration and

subdivision controls should extend over the entire metropolitan area of every city. This is an important element in preventing blight and should be required for every workable program.

It appears there is an increasing awareness that much will have to be done to make communities better places in which to live. Excellent opportunities exist for reshaping our cities through the urban renewal process, the interregional highway program, and master planning. Effective results can be achieved, but only if all programs are co-ordinated. It will take much hard work, patience, competent technical advice, and effective public relations. The future welfare of our cities demands it.

Shopper Origins and Destinations

WALTER THABIT AND NATHALIE LOBE

Mr. Thabit, trained in sociology, design, and city planning, worked for five years in housing development and rehabilitation; later in city planning and industrial research. He has done commercial and industrial studies and served as head of the Master Plan Section of the Baltimore City Department of Planning.

Nathalie Lobe, a trained economist, served in that capacity at Washington, and later at the Housing Bureau and Redevelopment Agency of Baltimore, Maryland. She also worked on a research project concerning transportation-to-shopping.

TO GET a general idea of where people shop and how they get there without spending the time or money an origin and destination study entails, a method is reported here that uses available data, plus statistics on sales and income, and does not require special field surveys.

It was recognized that no detailed analysis would be possible. But the need for any reasonable indication of shoppers' origins and destinations prompted the study. Determining which segment of shoppers caused Baltimore's decline in downtown business, for example, was based largely on speculation. The loss of downtown sales in Baltimore was attributed specifically to automobile shoppers from the suburbs. Information of this specific kind makes a study of shopper-travel worth while.

In recent literature, no other methods for determining such factors seem readily applicable. Reilly's law as modified for retail trade has not been fully adapted for the study of origins and destinations. Reilly's law as used for shopping center analysis is primarily a device to measure the attraction of automobile shoppers, not of all transportation media.

The authors wish to acknowledge the handicaps under which the study suffers: Admittedly the estimated movement of automobile shoppers, as well as assumptions concerning the distribution of total movement by origins and destinations, are often based on insufficient information. The bias potentially introduced, thereby, is a price

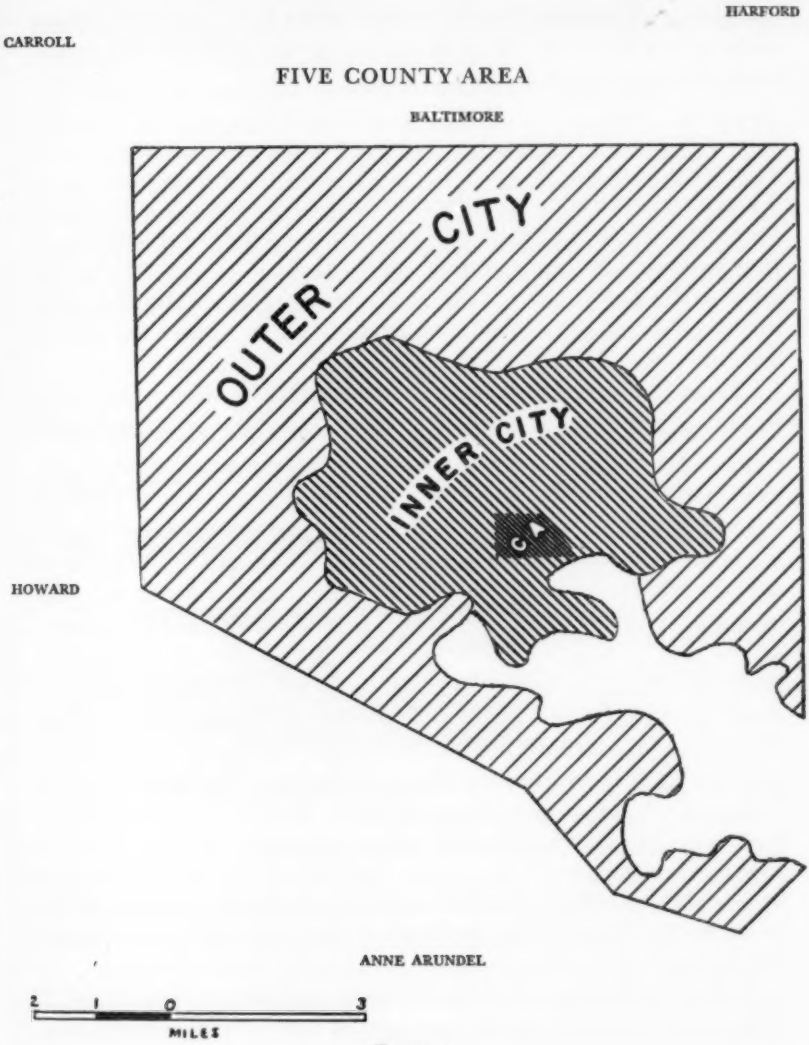

HARFORD
CARROLL
FIVE COUNTY AREA
BALTIMORE
OUTER
CITY
INNER CITY
C.A.
HOWARD
ANNE ARUNDEL
2
1
0
3
MILES

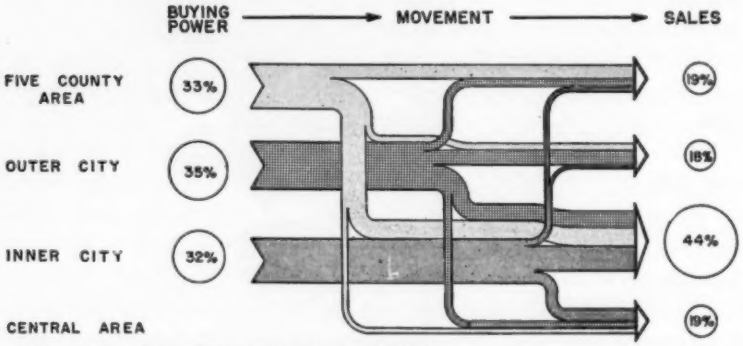
FIGURE 1.

paid for working with readily available data alone; dependence on these assumptions for similar studies is not recommended if further, better facts can be developed to use.

The Area and the Problem

The Baltimore trade area comprises four large divisions that follow generally concentric circles around the center of the city. Figure 1 shows graphically the geographic areas included in the study. Names given to the various parts of the trade area are clearly indicated, with the exception of the central area labeled CA, to denote the downtown shopping district.

Measurement of the origins and destinations of shoppers who live in one trade area and shop in another, is a major problem in this



SOURCE: Department of Planning, Baltimore, Maryland.

FIGURE 2. Origins and Destinations of Shoppers, 1948.

study. A second related, but lesser, problem involves quantifying the shoppers who live and shop in the same trade area. A third problem is to separate these origins and destinations by mode of travel.

Figure 2, showing the flow of origins and destinations of 1948 worked out by this method, may help at this point. Knowing the income and sales percentages for each trade area, the problem is to develop the flow diagram between them. The problems referred to above must be solved before the flow chart can be constructed.

Once a measurement of the total origins and destinations both within and between trade areas has been made, the problem re-

mains of separating these origins and destinations by mode of travel: mass transit, automobile, and pedestrian.

The method as finally developed can be separated into two parts: the development of the basic data, and the development of origins and destinations by mode of travel. The basic data include the measurement of the movement of people by foot, mass transit, and private automobile, as well as the tabulation of sales and income data. For the development of origins and destinations, a complicated check and balance between a theoretical sales-income distribution and movement is applied.

The Basic Data

Two basic measurements were involved for both mass transit and automobile movement in contradistinction to pedestrian movement. The number of mass transit and automobile passengers passing between trade areas (inter-area) is important in developing the origins and destinations, while the determination of vehicle-miles (the intra-area figure) is used to determine the percentage of mass transit riders within any trade area as compared with automobile and pedestrian shoppers.

For the same reasons, the number of passengers passing between trade areas and the number of vehicle-miles driven within a trade area must be found for automobile travel. Pedestrian travel, limited by assumption to travel within trade districts, need only be measured intra-area. For both transit and automobile travel, the period from 10 A.M. to 2 P.M. was used. This period tended to eliminate both rush hour traffic and the student rush on mass transit starting about 2:30. All the data collected therefore, both on mass transit and on automobile travel, were limited to this period.

Mass Transit Movement: Both inter-area and intra-area data were developed from Headway sheets of the Baltimore Transit Company. These sheets, used by bus and streetcar drivers, show the major points through which each vehicle passes, and the time the vehicle is due at such points. The process for determining the number of transit vehicles passing between trade areas and the number of vehicle miles within any trade area, though tedious, is a relatively

simple job. Basically, it involved plotting all transit routes running between 10 A.M. and 2 P.M., and extracting the number of vehicles running within and between trade areas. The results are shown in Table I.

For mass transit, twenty-five persons per vehicle entering (as found in the cordon count of the Mass Transportation Committee Report),[1] cannot realistically represent the average number of riders in the outer parts of the city. It was therefore assumed that the average number of transit passengers in the four trade areas would follow, roughly, the densities of day-time population.

While approximately twenty-five persons per vehicle entered the downtown area, the number per vehicle riding within the central area is probably somewhat higher; assume twenty-seven. Working back from this premise, and taking into account the densities of day-time population, the persons per mass-transit vehicle are estimated at sixteen for the inner city, seven for the outer city, and four for the five-county area. While no check was made on this procedure, it was one way of reducing riders per vehicle with distance from the central area.

Table I

MASS-TRANSIT VEHICLE MILES AND INTER-AREA VEHICLES BY TRADE AREA
TWO DIRECTIONS, 1955

Area	*Vehicle Miles*	*Vehicles Between Trade Areas*
CENTRAL AREA	977	
Inter-Area		1,952
INNER CITY	5,829	
Inter-Area		1,554
OUTER CITY	4,822	
Inter-Area		587
FIVE-COUNTY AREA	N.A.*	

N.A.* Not Available.

Mass transit vehicles passing between trade areas are shown in Table I preceding. Passenger totals were worked out by multiplying the number of persons per vehicle by the number of vehicles passing

1 *Report to the Mayor by the Committee on Mass Transportation*, Baltimore, Md., April, 1955.

each boundary point. The results of this operation are shown in Table II, the basic table on movement used in the development of origins and destinations.

Automobile Movement

Having no precise data on automobile movement, a method of arriving at an approximation of the magnitude of automobile travel was developed. From the department of traffic engineering, a map showing scattered cordon counts and lane capacities of most major streets was provided for use in the study. Neither of these items by itself could be considered comprehensive enough to provide an adequate picture of total traffic movement. A use-capacity formula was therefore developed combining both pieces of information.

A large sampling of streets for which both lane capacities and cordon counts were available was made, and a formula was derived by which all streets were classified as low, medium, or high use-capacity. As part of the formula, combinations of lane capacities and average counts derived from the sample were assigned to each class as shown in Table III.

Table II

SHOPPERS PASSING BETWEEN TRADE AREAS
AUTOMOBILES AND MASS TRANSIT, 1955

Vehicle	*Five-County Area to Outer City*	*Outer City to Inner City*	*Inner City to Central Area*
Mass Transit			
Number of Vehicles	295	777	976
Shoppers/Vehicle	4	16	25
Total Shoppers	1,180	12,400	24,400
Automobile			
Number of Vehicles	60,180	68,400	25,700
Shoppers/Vehicle	1.5	1.5	1.5
Total Shoppers*	153,000	173,000	65,000
Total Vehicular Shoppers	154,000	185,000	90,000

* Shoppers on major streets divided by 60 percent.

The combination of lane capacity and actual flow made it necessary in many cases to place streets with the same lane capacity in different classifications. For example, a two-lane street carrying 250 vehicles an hour or less, was classified as a low use-capacity street, while a two-lane street carrying 400 or more vehicles an hour was classified as high use-capacity.

As the classifications were finally established for use in measuring automobile travel, the modal average, shown in Table III, was used for all streets. To get the number of vehicles moving during the four-hour time period, these averages were multiplied by four and again by two since the averages were based on one direction travel only. All streets were then mapped according to their classifications, measured for length, and the results computed for inter-area and intra-area figures shown in Table IV.

Table III

AVERAGE HOURLY COUNT OF AUTOMOBILES ON MAJOR STREETS BY USE-CAPACITY CLASSIFICATION

Classification	*Free Moving Lanes*	*Average Count**
Low Use-Capacity	1	250
	1½	200
	2	100
Average		200
Medium Use-Capacity	1	500
	1½	400
	2	300
	3	250
Average		350
High Use-Capacity	2	800
	3	650
Average		725

* In one direction.

To convert the data on inter-area vehicles to the number of passengers, an estimate of persons per vehicle (data found in the report of the Committee on Mass Transportation previously referred to) was used. In 1945, moveover, the origin and destination study made for Baltimore showed that by automobile, the number of persons

Table IV

AUTOMOBILE VEHICLE MILES AND INTER-AREA VEHICLES, MAJOR STREETS IN TWO DIRECTIONS, 1955

Area	*Vehicle Miles*	*Vehicles Between Trade Areas*
CENTRAL AREA	19,888	
Inter-Area		51,901
INNER CITY	305,198	
Inter-Area		133,800
OUTER CITY	419,859	
Inter-Area		122,600
FIVE-COUNTY AREA	N.A.*	

N.A.* Not Available.

per vehicle was found to vary little between the inner and outer parts of the city. Consequently, the 1.5 persons per automobile entering the downtown cordon line was used as the average number of persons per automobile in all four trade areas.

It was assumed that major streets account for 6 percent of all traffic in Baltimore based on the downtown cordon count by the Mass Transportation Committee. All totals for automobile traffic were therefore adjusted upward to 100 percent using the basic data in Table IV plus the estimated figures for average persons per vehicle in private automobiles. The final figures for passengers passing between trade areas by automobile are also shown in Table II preceding.

Pedestrian Movement

On the basis of a few sample studies of the percentage walking to shopping, it was determined that 35 percent of the inner city shoppers walk, that 25 percent walk in the outer city, and that 15 percent walk in the five-county area. These percentages included pedestrians who originate from work as well as from home. It was believed that the shopper walking from work was included in the vehicular measurements, however, and should be excluded from the pedestrian estimates.

Percent of walking shoppers was then reduced to the percent walking from home. Assuming that walking shoppers originate from

home in the same proportions that all shoppers originate from home, the walking shoppers can be reduced to those proportions. Based on studies made in other cities, about 80 percent of inner city shoppers, 90 percent of outer city shoppers, and about 95 percent of five-county area shoppers originate from home.[2]

As 35 percent of all inner city shoppers walk and 80 percent of all inner city shoppers originate from home, then approximately 28 percent walk from home. Similarly, the 25 percent walkers in the outer city reduced by 90 percent leaves 22 percent walking from home, and the 15 percent in the five-county area reduced by 95 percent leaves 14 percent walking from home. The percent of walking shoppers is translated into a numerical quantity later in the computations of origins and destinations.

Sales and Income Data

In searching for a means to separate origins and destinations of shoppers crossing trade area boundaries, the sales and income data shown in Table V were utilized. But to use sales and income data as the tool for separating origins and destinations necessitated two major assumptions.

Table V

SALES AND INCOME BY TRADE AREA, VOLUME AND PERCENT, 1948

	Sales		*Income**	
	Volume 000	*Percent*	*Volume 000*	*Percent*
Central Area	242,689	18.6	1,647	.1
Inner City	574,455	44.1	44,075	31.6
Outer City	234,529	18.0	492,795	35.0
Five-County Area	251,706	19.3	N.A.	33.3
Total Trade Area	1,303,379	100.0	N.A.	100.0

NOTES: * 1950.

SOURCES: 1. Department of Planning Estimates.
2. U. S. Bureau of Census, Census of Population, 1950.
3. Shaw, Leslie C., *Baltimore News-Post*, Baltimore, Md.

2 Voorhes, Alan M., Sharpe, Gordon B., and Stegmeier, Joseph T., *Shopping Habits and Travel Patterns*, Washington, D. C., 1955.

The first assumption is that destinations of shoppers are in the same proportion as the distribution of sales percentages. There is an implied assumption here that shoppers congregate in each trade area in proportion to its percentage of sales. This does not take into account variations in dollars per transaction. But decentralization of department stores and supermarket development have initiated a tendency toward a higher dollar purchase per shopping trip in the suburbs which contributes toward uniformity in dollar transactions throughout a trade area.

The second assumption is that the origins of shoppers are in the same proportions as the distribution of income percentages. This implies that no variations exist in the proportions of income spent for retail goods from one trade area to another. This is obviously not the case, but it is likely that slowly disappearing income extremes are contributing toward a uniform proportion of income spent for retail goods throughout a trade area.

Keeping these limitations in mind, a single percentage can be used to describe the spendable income in any trade area, or the sales which result from that income as the shopper spends it.

Validity of the Data

Although desirable to test these measures according to the principles of statistical inference, the measurements were not refined to a point where such tests were feasible. Consequently, the validity of the measurements could not be verified, but some limited survey material was found for comparison with the findings on vehicular travel. Little was available for pedestrian measurements. Sales and income were taken directly from U. S. Census reports.

The survey data for comparison with the vehicular measurements come from a field count made of the downtown area only, made in 1955. The survey, a count of public and private vehicles entering and leaving the downtown area, was made in conjunction with a report on mass transportation entitled "Report to the Mayor by the Committee on Mass Transportation," and will be referred to here as the Committee's Report.

According to Table I, 1,952 mass-transit vehicles moved in and out of the central area between 10 A.M. and 2 P.M. Half of that

figure, or 976, represents the mass-transit vehicles entering the central area during those hours. According to the committee's report, on the other hand, 910 mass-transit vehicles entered the cordon line between 10 A.M. and 2 P.M. In the committee's report, moreover, the count was made at a cordon line surrounding a downtown somewhat larger to the north than the central area used in this study.

As the committee's cordon count was taken on the larger downtown area, it should normally be the higher of the two figures, but it was not. This may be explained by a major curtailment of transit service which took place after the transit schedules for this study had been analyzed and before the time of the committee's cordon count. Further, because of the known inadequacies of the use-capacity formula, more care was taken in comparing the two sets of data on automobile movement. Adjustments were therefore made for the dissimilar downtown areas and for differences in streets.

The use-capacity measurements were recomputed for the cordon line to include as far as possible the same major streets as those used by the committee on mass transportation. The total findings in the two sets of data fell within 1 percent of each other. Individual computations by the use-capacity formula, however, vary by as much as 44 percent from the cordon count on the same street. At best, this could signify that errors among the individual streets measured by the use-capacity formula are largely cancelled out by each other; at worst a 1 percent difference could be largely coincidence. Despite the adjustments made to compare the two sets of data, their incomparability was too pronounced to be a reliable test.

As previously stated there was no survey material available for comparison with the vehicular measurements made for the inner city, outer city, and five-county area, and very little material was available to test the validity of the pedestrian percentages within the trade area.

Origins and Destinations

In developing the total origins and destinations by trade area, two problems are involved: first, the A problem, is that of distinguishing the destinations of shoppers who cross any particular trade area boundary. The second, the B problem, concerns the number of shoppers from any trade area who shop within that trade area.

After the total origins and destinations have been developed, the further problem remains of separating origins and destinations into shoppers traveling by mass transit, private automobile, and foot. This is essentially a problem of drawing proportions between mass transit and automobile pedestrians for inter-area travel, and apportioning all three transportation media according to the percentage of each for intra-area movement.

Total Origins and Destinations

In Figures 3 and 3a, the A problem is typified by the unknown number of shoppers from the ranks of 154,000, 185,000 and 90,000 which finally end up in the central area. (See Table II for the derivation of these totals.) Shoppers from the five-county area or A_1, comprise

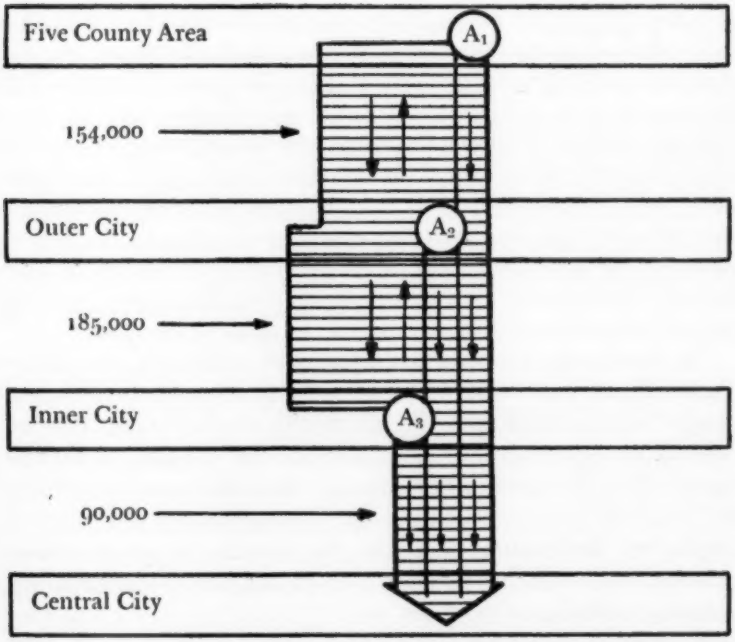


FIGURE 3. The Problem of Distinguishing Destinations from Total Movements between Trade Area Boundaries.

Note: A_1—A_2—A_3—the Total Number of Shoppers destined for the Central Area.

some portion of the total movement of shoppers between the five-county area and outer city.

Shoppers from the outer city destined for the central area, or A_2, are found, along with A_1, in some proportion to the 185,000

From \ To	Central City	Inner City	Outer City	Five County Area
Central City				
Inner City	A_3	B		
Outer City	A_2		B	
Five County Area	A_1			B

FIGURE 3a.

shoppers passing between the outer city and inner city. Shoppers from the inner city destined for the central area, or A_2, are found, along with A_1 and A_2, in some proportion to the total movement of shoppers between the inner city and central area. A_1, A_2, and A_3 comprise the total movement of shoppers or 90,000 between inner city and central area, because the movement of shoppers from the central area outward was considered too small to compute.[3]

In developing the total destinations by trade area, the data in Tables II and V are used. The data in Table II on the movement of people between trade areas are not strictly shopper traffic. For purposes of this study, however, it was assumed that the shopper percentage of all traffic passing between any two trade-area boundaries would be the same at any boundary. Throughout the discussion on origins and destinations, therefore, the number of people moving between trade areas will be referred to as shoppers, a shortened way of saying an index of shoppers.

Origins are based on income percentages, destinations on sales percentages, and the movement of shoppers is the catalyst which

[3] Or less than .1 percent of sales originate in the central area.

transforms this income into sales. The question to answer is how much of inner city income is spent in the inner city and how much elsewhere; how much of inner city sales comes from inner city income, and how much from the outer city and five-county area? The possibilities of various distributions are infinite, but guided somewhat by the principles of Reilly's Law, a theoretical distribution of all income to sales was made which accounts for the expenditure of buying power as well as the accumulation of sales in any trade area.

This theoretical distribution was checked against the known numbers of shoppers passing between trade areas. The tentative theoretical distribution shown in Table VI was developed to show the origins and destinations of shoppers in 1948.

Checking the Theoretical Origins and Destinations: Limiting the analysis to the number of shoppers with origins and destinations in different trade areas (because only the number of shoppers between trade areas is known), the known movement of shoppers between trade areas is used to check the validity of the theoretical distribution of sales and income. The number of shoppers between any two trade areas is theoretically equivalent to the percentage of income that has to pass between those two trade areas on its way to becoming an equal percentage of sales. In cases where the sales-income percentages do not balance with the known number of shoppers, the theoretical distribution must be in error.

Table VI

BUYING POWER AS PERCENT OF SALES, BY TRADE AREA, 1948
TENTATIVE TABULATION

To:	*Central Area*	*Inner City*	*Outer City*	*Five-County Area*	*Total Income*
FROM:					
Central City	.1	.0	.0	.0	.1
Inner City	7.3	18.4	3.2	2.7	31.6
Outer City	5.6	15.2	10.0	4.2	35.0
Five-County Area	5.6	10.5	4.8	12.4	33.3
Total Sales	18.6	44.1	18.0	19.3	100.0

The sales-income percentages, which necessarily cross the boundary between trade areas, are shown in Table VII after being totaled from Table VI. As can be seen in Table VII, the 154,000 shoppers known to have crossed the five-county area—outer city boundary line should be equivalent to 27.8 percent of all spendable income as well as of all sales of the entire Baltimore trade area.

It is possible at this point to find differences between the number of shoppers per percent passing through different trade-area boundaries, and to realize that the theoretical distribution is inadequate. This simple check was not recognized at the time the study was made, but perhaps even more important in going further is the fact that every original distribution in the distribution of sales-income would have to be changed in any case of inadequacy. This led to the use of a more detailed check.

Table VII

TOTAL SALES-INCOME PASSING TRADE-AREA BOUNDARIES

Boundary Line	*Sales-Income*	*Origins*	*Destinations*
Five-County Area and Outer City (154,000 Shoppers)	27.8%	Five-County Area ⟶	Outer, Inner, Central Areas
		Outer City ⟶	Five-County Area
		Inner City ⟶	Five-County Area
Outer City and Inner City (185,000 Shoppers)	42.8%	Five-County Area ⟶	Inner, Central Areas
		Outer City ⟶	Inner, Central Areas
		Inner City ⟶	Outer, Five-County Areas
Inner City and Central Area (90,000 Shoppers)	18.6%	Five-County Area ⟶	Central Area
		Outer City ⟶	Central Area
		Inner City ⟶	Central Area

The full distribution of shoppers was therefore made to replace the sales-income percentages with numbers of shoppers. Let N equal the number of shoppers and let P equal the equivalent proportions of income destined for payment in sales to and from each area.

The P breakdowns (the theoretical distribution), shown in Table VI, must be translated into the equivalent N factors. The basis for this translation is the known number of shoppers crossing trade-area boundaries.

If we number the central area, inner city, outer city and five-

county area, 1, 2, 3, and 4, respectively, the N factors to be determined can be shown as follows:

	To:	1	2	3	4
	1	N_{11}	N_{12}	N_{13}	N_{14}
From:	2	N_{21}	N_{22}	N_{23}	N_{24}
	3	N_{31}	N_{32}	N_{33}	N_{34}
	4	N_{41}	N_{42}	N_{43}	N_{44}

In ascertaining, for example, the number of shoppers originating in the inner city and destined for the central area, or N_{21}, the problem is to devise a method for extracting N_{21} from the 90,000, or X, shoppers passing between inner city and central area.

The general theory is that if N shoppers, or 90,000, carry the equivalent P income, equal to 18.6 percent of total income, across the inner city–central area boundary, then the relationship of 18.6 percent to any one of its component P factors (which have the same sub-numbers as the N factors) can be applied to 90,000 to determine the corresponding N components. Shoppers originating in the five-county area and destined for the central area are determined as follows:

$$N_{41} = \frac{P_{41}}{P_{41}\ P_{42}\ P_{43}\ P_{34}\ P_{24}}\ (X) \qquad \text{or}$$

$$N_{41} = \frac{5.6}{27.6}\ (154{,}000) = 30{,}000 \text{ shoppers}$$

The origins and destinations for inter-area shopping based on the theoretical tabulation in Table VI are shown graphically in Figure 4 following. The double and triple sets of figures represent the various ways in which the quantities for a single movement can be measured.

For example, from Table VII, it can be seen that the movement of shoppers from the five-county area to the central area is present at every boundary point, and because of the different number of total shoppers passing between each of the three boundaries, it can be computed in three different ways. Each of the three ways is based on 5.6 percent of five-county area income which is central area sales (from Table VI). These double and triple sets of figures also represent the potential points at which an invalid distribution will show

up and are consequently used to check the validity of the theoretical distribution.

The wide discrepancy between the double and triple sets of figures in Figure 4 indicates that the theoretical distribution allows

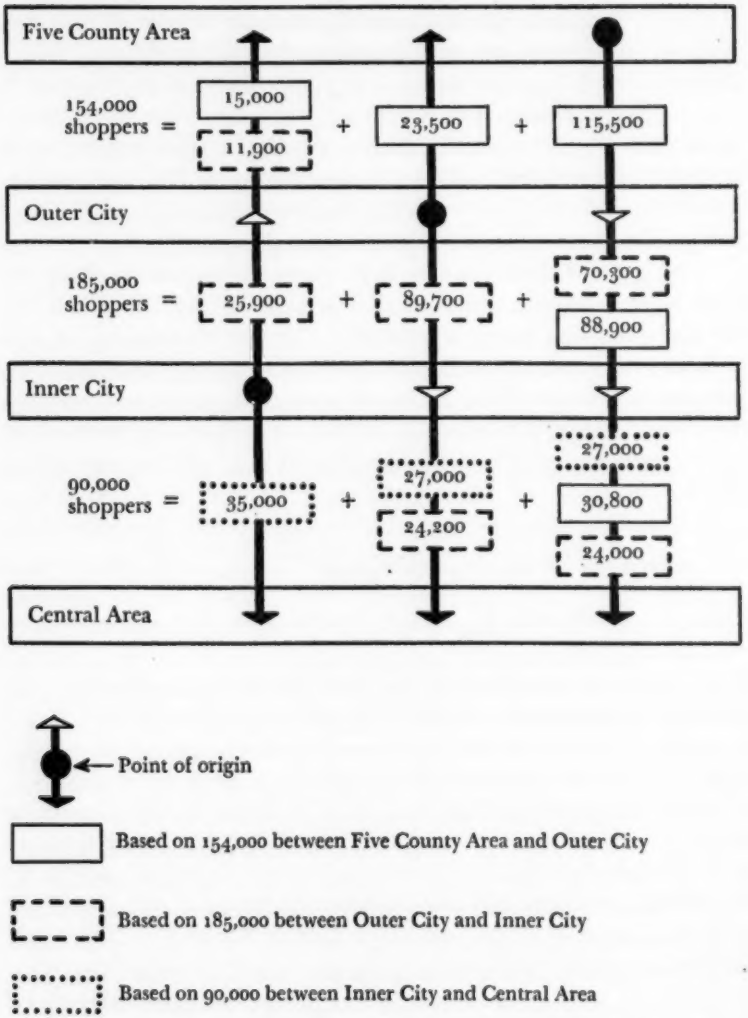


FIGURE 4. Tentative Distribution of Shoppers between Trade Areas.

wide variations in the number of shoppers originating in one area supposed to have passed a particular boundary on the way to another. The widest difference, for example, would mean that somewhere between 4.8 percent and 9.3 percent of Baltimore trade-area sales and income could be five-county area shoppers crossing the outer city-inner city boundary to shop in the inner city or central area. This is in contrast to the 4.8 percent assigned on the theoretical basis. Obviously this range is too high.

By taking the simple average of the range and re-working the theoretical distribution, the resulting new N components fall in closer harmony to the actual theory. Using such a procedure, the theoretical distribution was adjusted and readjusted many times. The final theoretical distribution shown in Table VIII resulted in duplicating figures which are within 2 percent of the percentages shown in Table VIII.

Table VIII

BUYING POWER AS PERCENT OF SALES BY TRADE AREA, 1948
FINAL TABULATION

FROM:	*Central Area*	*Inner City*	*Outer City*	*Five-County Area*	*Total Income*
To:					
Central Area	.1	.0	.0	.0	.1
Inner City	8.7	18.0	1.8	3.1	31.6
Outer City	5.3	12.6	11.6	5.5	35.0
Five-County	4.5	13.5	4.6	10.7	33.3
Total Sales	18.6	44.1	18.0	19.3	100.0

No attempt was made to assess the magnitude of error resulting from the procedure, but it is likely that the resulting distribution is a reasonably accurate generalized indication of how income crosses boundary lines in the hands of shoppers on its way to becoming sales. The N components resulting are shown in Table IX following.

Shopping Within Trade Areas

Table IX below shows the B problem as well as the finally filled out origins and destinations of shoppers passing between trade areas.

The total inter-area movements are 285,000, which represent 60 percent of the sales income distribution in Table VIII. If 285,000 shoppers account for 60 percent of sales-income, then 475,000 repre-

Table IX

ORIGINS AND DESTINATIONS OF SHOPPERS PASSING BETWEEN TRADE AREAS
1948

To:	*Central Area*	*Inner City*	*Outer City*	*Five-County Area*
FROM:				
Central Area	(B)	120	0	0
Inner City	43,600	(B)	7,500	15,000
Outer City	24,950	54,900	(B)	26,600
Five-County Area	23,725	61,700	25,300	(B)

sents 100 percent or all shoppers. Then, by subtraction, the 190,000 remaining shoppers are intra-area shoppers, and must be apportioned on the basis of the sales-income distribution shown in Table VIII above. For any one trade area, the number of shoppers with origins outside the area is subtracted from the total shoppers originating from that area, and the remainder represents shoppers with origins and destinations within the area. This quantifies the B problem, and completes the breakdown of origins and destinations, shown in Table X following.

Table X

ORIGINS AND DESTINATIONS OF SHOPPERS BY TRADE AREA, 1948

To:	*Central Area*	*Inner City*	*Outer City*	*Five-County Area*	*Total*
FROM:					
Central	355	120	0	0	475
Inner	43,600	84,000	7,500	15,000	150,100
Outer	24,950	54,900	59,800	26,600	166,250
Five-County	23,725	61,700	25,300	47,450	158,175
Total	92,630	200,720	92,600	89,050	475,000

Origins and Destinations by Mode of Travel: Origins and destinations were next separated into shoppers traveling by mass transit,

automobile, and foot. As discussed earlier, it was assumed that the A group of shoppers with origins in one trade area and destinations in another all ride to shopping. From the preceding Table II, "Shoppers Passing Between Trade Areas, Mass Transit and Automobile, 1955," the percentage of shoppers using transit is computed at .7 percent between five-county area and outer city, 7 percent between outer and inner cities, and 26 percent between the inner city and central area.

How the A group of shoppers was classified by mode of travel can best be shown by example. Consider shoppers traveling to the central area, where practically all of the shoppers originate outside the area. If .7 percent of shoppers passing between the five-county area and outer city went by transit, and, according to Table X preceding, 23,725 were destined for the central area, then approximately 166 travel to the central area from the five-county area by transit. The rest of the transit shoppers must be distributed among the other three areas. The 48,675 shoppers who travel from the five-county area and the outer city to the central area pass between the outer and inner city line, where 7 percent or 3407, travel by transit. Since 166 of these transit riders came from the five-county area, 3407 less 166, or 3241, transit riders came from the outer city to the central area by transit.

Shoppers from the five-county area, outer city, and inner city, destined for the central area, numbered 92,275, and they all passed between the inner city and central area, where 26 percent ride by transit. Or 23,992 shoppers travel between the inner city and the central area by transit.

But 166 came from the five-county area and 3241 came from the outer city; therefore, the rest, or 20,585, traveled from the inner city to the central area by transit. The same procedure was used in determining the transit shoppers traveling to inner city, outer city, and five-county area. In all cases, total shoppers, less transit shoppers, are automobile shoppers.

The mode of travel for the B group of shoppers, with origins and destinations in the same trade area, involves mass transit, automobile, and pedestrian means. As discussed earlier, it was assumed that all shoppers walking from home originate and shop in the same trade area, which in most cases must be so.

The percentage of shoppers walking from home was applied to the total number of shoppers destined for each trade area. The resulting quantity are shoppers who walk from home by trade area. Deduct these from the total shoppers with origins and destinations in a trade area, and the remainder ride by mass transit or automobile.

Riding shoppers who live and shop in the same trade area were separated by mass transit and automobile on the basis of vehicle miles. Using vehicle miles eliminated the time factor and permitted comparability of data for different-sized trade areas. Based on vehicle miles, Table XI, below, gives the mass-transit shoppers as a percent of all shoppers who live and shop in the same area. Because of the negligible number of resident shoppers, no computations were made for the central area.

Table XI

MASS TRANSIT SHOPPERS AS PERCENT OF ALL RIDING SHOPPERS WITHIN TRADE AREAS, 1955

	Automobile		*Mass Transit*			
	Vehicle Miles +000*	*Person Miles** +000*	*Vehicle Miles +000*	*Person Miles*** +000*	*Total Person Miles +000*	*Percent Mass Transit Shoppers*
Five-County Area	N.A.	N.A.	N.A.	N.A.	N.A.	.3%****
Outer	706	1,059	4.8	38	1,097	3.0%
Inner	512	768	5.8	93	861	11.0%

NOTES: * Major Streets + 60%.
** Vehicle Miles times 1.5 persons per vehicle.
*** Vehicle Miles times 7 and 16, for Outer and Inner Cities.
**** Estimated.

Application of the percent of mass-transit shoppers to all riding shoppers with origins and destinations in the same trade area was the final step in obtaining numerical entries for the "Origins and Destinations by Mode of Travel, 1948," as shown in Table XII.

Using sales and income data for 1954, as applied to the basic measurements made previously, another analysis of origins and des-

Table XII

Origins and Destinations by Mode of Travel, 1948

To → / From ↓	Total			Central Area			Inner City			Outer City			Five-County Area		
	Auto	*Mass Transit*	*Pedes.*	*Auto*	*Mass Transit*	*Pedes.*[1]	*Auto*	*Mass Transit*	*Pedes.*[2]	*Auto*	*Mass Transit*	*Pedes.*[3]	*Auto*	*Mass Transit*	*Pedes.*[4]
Total	348,800	37,463	88,737	68,283	23,992	355	138,280	11,340	56,000	66,265	1,735	19,700	75,972	396	12,682
Central Area	85	35	355	0	0	355	85	35	0	0	0	0	0	0	0
Inner City	70,108	23,992	56,000	23,015	20,585	0	25,200	2,800	56,000	6,998	502	0	14,895	105	0
Outer City	133,993	12,557	19,700	21,709	3,241	0	51,726	8,074	0	34,144	1,056	19,700	26,414	186	0
Five-County Area	144,614	879	12,682	23,559	166	0	61,269	431	0	25,123	177	0	34,663	105	12,682

Notes: [1] Based on the assumption that all residents of the Central Area shop by foot.
[2] Based on 28% of shoppers walking from home.
[3] Based on 22% of shoppers walking from home.
[4] Based on 14% of shoppers walking from home.

Source: Department of Planning, Baltimore, Maryland.

tinations was prepared. The procedures for quantifying problems A and B by mode of travel follow those used for the 1948 analysis.

Unfortunately, it was necessary to apply the same traffic volume data to income and sales percentages for both 1948 and 1954. Because the measurements, themselves, are derived largely from 1954–1955 traffic volume data, it is probable that the origins and destinations for 1954 represent the more realistic picture of travel to shopping. On the other hand, these origins and destinations prepared for both 1948 and 1954, did provide a basis for describing some major trends in the travel pattern of shoppers.

An analysis of travel patterns by origins and destinations of shoppers has been prepared. By eliminating the large field staff and the elaborate coding and tabulating procedures that a field survey involves, the cost of this study was relatively low, and the time allotted relatively short. Without question, the methodology limits the study in both accuracy and precision. Its main contribution must be a broad general picture of travel patterns to shopping.

The study is unusual in that it comprehensively approaches a fairly specific problem. While origins and destinations are oriented to large areas within Baltimore and the surrounding counties, they concern only travel to shopping, and nothing more. Comprehensive studies of origins and destinations are many. One made in Baltimore in 1945–1946 is typical.

It shows traffic volume to and from major divisions of the city, but has no area breakdowns by mode of travel or trip purpose. Consequently, it is of little value for application to a specific problem, such as travel to shopping. On the other side of the scale are the specific studies which give all the details in a problem but are generally limited to a few small areas; their limited scope makes it risky to draw any general conclusions on travel patterns. Somewhere between the too broad and the too specific, lies the approach made in this study.

On the basis of this study, it can be concluded that, with very definite limitations, there are possibilities for deriving origins and destinations of shopper travel without a comprehensive field survey for that purpose. The potentialities of this methodology would depend upon overcoming some of the major limitations as stated throughout the paper. Where the available data were weakest, supplemental survey material should have been collected.

While a more accurate means of verifying the conclusions at each step of the analysis is called for, in most instances it was the limitations in the available raw data that prohibited comprehensive statistical verification. Whether the method outlined in this study is worth further investigation and improvement can best be decided by those in the field of research, who find a need for basic data on transportation to shopping.

City's Traffic Efficiency Increased By New Street System in Oklahoma

J. H. ROBINSON AND GEORGE W. BARTON

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This article was prepared in collaboration with George W. Barton, owner and director of George Barton and Associates, traffic engineering consultant firm of Evanston, Illinois. Mr. Barton is a member of the Institute of Traffic Engineers and a registered professional engineer in Illinois.

FOLLOWING the opening of the Oklahoma Strip, Oklahoma City has grown from a small town of 4,000 in 1890 to the forty-fifth largest city in the United States in 1950. During those sixty years, the population increased sixtyfold—the most dramatic growth experienced by any city of comparable size. In twelve selected cities, including Oklahoma City, the average population tripled since 1900. Oklahoma City's population in 1950 was twenty-four times as great as in 1900. Inescapably, the growth brought problems.

A primary need was overall improvement of our street transportation. Leaders believed a long-range project could develop a system distinctly enviable by comparison with similar cities. Upon the advice of the Traffic and Transportation Commission, the city council authorized a study of our street traffic. In 1953, the city completed a fourteen-month traffic survey. Based on the results and the advice of our traffic consultant, the city in 1954 adopted the survey recommendations in their entirety. They included widening and otherwise improving primary streets, a one-way street program, and suggestions for obtaining financial aid to carry out the plan. Funds were not immediately available for the entire program; state legislation was necessary to acquire enough money. The program was set up in stages. In proposing the first stage, it was em-

phasized that full efficiency of the plan could not be accomplished until all elements were complete.

"Traffic Program—Stage 1," called for installing twenty-six miles of one-way streets, an unbalanced traffic flow on streets with off-set

FIGURE 1. Oklahoma City's One-way Street System.

center lines, reversible two-way streets in conjunction with one-way streets, new interconnections, installation and retiming of all traffic signals, and special pedestrian signals and crossings, plus numerous

parking restrictions. Work on the first stage was in use by May 31, 1955. (Figure 1.)

Changing to One-Way Streets

The one-way system was put into effect because it allowed maximum retention of curb parking, afforded the best facilities for pedestrians, developed the maximum capacity, and avoided change as the city grew. This system tied into a belt of distributor streets provided by means of 9th and 10th Streets on the north, Oklahoma-Walnut on the east, Shartel-Lee on the west, and South 4th and 5th Streets on the south side.

The main street of the central business district was installed for one-way operation to simplify traffic movement on that street and especially to make possible desirable handling of the important pedestrian traffic. Since there are no off-street parking facilities on Main Street from a point one half block east of Broadway to a point one half block west of Walker (approximately five blocks) motorists going to a building on Main Street are required to seek a parking facility to the north, a maximum of three blocks; or to the south, to a maximum of two blocks. Also the direction of Main Street harmonized with connections for north-south streets at either side of the business district.

In the downtown area, prior to the 1955 installation of the one-way streets, speed and delay checks indicated that speeds on many of the principal streets averaged as low as four miles an hour during the afternoon rush. Delays were due chiefly to excessive volumes of traffic, poor signal co-ordination, and conflicts between turning vehicles.

The time required to clear traffic out of the central district during the peak evening-rush hours required one and a half hours. The speed on these same principal streets now averages on the east and west movement nineteen to twenty-one miles an hour and on the north-south movement nineteen to twenty miles an hour. The time required now to clear traffic out of the central business district is from fifteen minutes to a maximum of twenty-five. This time is also based on the overall increase of 2.3 percent in the 1956 volume of traffic in the central business district.

In May 1956, traffic counts at forty-three places on the cordon line of the central business district were taken to compare with counts taken prior to the first-stage program installation. These counts showed that the overall traffic pattern entering and leaving the central district were more generally distributed over a wider pattern by easier accessibility to the east-west and north-south arteries than in 1953.

The paramount objective of the one-way street system is greater safety, convenience, and comfort for patrons and employees of the central business district. Through-traffic interested only in getting through the district as quickly as possible should be diverted around it. Expressways under construction approaching the downtown area from northeast and northwest, passing south of the district, will produce a significant change in the downtown traffic pattern. It will cause traffic approaching from the north and northwest to enter the downtown area from the south where the traffic burden is least.

Suitable access to the expressway system will also be obtained for east-west routes such as Main Street. A better distribution to the east and west will be produced. Ramps leading from the expressway to the downtown district can materially affect the pattern within the district. If the principal ramps lead to the north-south one-way streets on the periphery of the business district, movement through the heart of the district will be lessened.

Articles have been written on one-way streets with data supporting their advantages. Few of the public and none of those responsible for installing it doubt that our related one-way street system improves the flow of vehicular traffic, gives better, safer pedestrian movement at nominal cost compared with the extensive cost of street-widening construction.

New Signal System Installed

Prior to the adoption of the one-way street system in the central district, all traffic signals operated on a fifty-five-second cycle during rush hours and on a fifty-second cycle during the non-rush period. There was no special pedestrian movement or lights. In general, all traffic signals were timed progressively inbound during the morning rush at a speed of approximately nineteen miles an hour for north

and south movements and twelve to seventeen miles an hour for east and west movement.

During the evening rush period, the progression was reversed for eastbound traffic. On the mid-day non-rush period the progression was staggered with every other street outbound and co-ordinating with our only two one-way streets at that time, which were North Harvey and North Hudson. When the first phase of the one-way streets was put into effect, the cycle length of all signals in the downtown district was increased to sixty-five seconds during the rush periods and to sixty seconds during the non-rush or mid-day period. The traffic signal system was substantially the same as the old non-rush system. Alternating the progression on every other street to agree with the direction of the new one-way streets, we were able to increase the progression to twenty-two miles an hour.

In the downtown loop, where turning movements and pedestrians are numerous, direction arrows and pedestrian signal lights were installed to eliminate the pedestrian and vehicle conflicts. In addition, two mid-block signalized pedestrian crossings were introduced into this system on the main street. (Figure 2.) Their results were remarkable. In addition to giving more convenience and freedom of movement to pedestrians, the progression of through westbound vehicles was good. Observations at the mid-block crossings indicated jay-walking as nil. In addition to seventeen new signal light installations, plus special pedestrian and directional arrows, special lane signal lights were installed for reversible lanes on the South Robinson Underpass, a main arterial street from the south leading into the central business district. Approximately twenty miles of interconnecting underground signal cable were installed. The total cost of all signal installation was nominal, $43,800, as city signal crews under force account were used.

Unbalanced Two-Way Streets

In conjunction with one-way streets, it was necessary to continue North Broadway, a sixty-eight-foot street, one and one-fourth miles long, as a two-way artery, mainly because the street system east of this north and south artery is irregular as a result of the Santa Fe Railway tracks adjacent to the east, dividing the east and west traffic

movement at the east edge of the central business district. Since the street adjacent to North Broadway directly to the west, North Robinson, was to be made a one-way street southbound, it was logical to use North Broadway as an unbalanced two-way street favoring northbound traffic from the central business district. To balance the southbound traffic capacity that would move to the street west—North Robinson—the dividing line on North Broadway between opposing directions of travel was established along a line twenty-seven feet from the west curb. With curb parking, this allowed three lanes northbound and two south. Curb parking at the east curb was eliminated during the evening rush period, which produced four lanes northbound.

Traffic signals on this street were timed progressively for northbound traffic during the day with poor progression for southbound traffic, to encourage southbound traffic to use the new one-way streets, such as North Robinson, the adjacent street to the west. An important step was to determine the actual starting and ending points of this unbalanced two-way artery. The termination was reasonably established since the new one-way streets directly to the west began at N.W. 16th Street for southbound traffic with a perfect interconnecting point of the two streets being N.W. 16th, a thirty-foot street, providing three ten-foot lanes for one-way movement west into North Robinson. Selecting an origin point for this two-way unbalanced street was more difficult. From traffic counts taken prior to this street installation it was determined there would be sufficient capacity for the present volume and anticipated future increase by making this street originate at Grand and Broadway, a block south of Main Street. By this arrangement southbound traffic on this unbalanced street could only make a left turn to the east. This type of operation did not adjust itself for the following reasons:

(a) Though a special split green arrow on the signal was installed at Grand and Broadway for southbound traffic—with Broadway to the south a one-way street north, and Grand Avenue to the west a one-way street eastbound—the allotted time for southbound traffic for this movement on a split green signal had to be at a minimum because of the rising volume of traffic on the one-way street entering the intersection.

(b) Grand and Broadway is a difficult intersection to control

for two-way traffic because of the alignment of the north and south curbs on the east side of North Broadway. This makes the intersection off-set as much as forty-five feet for north and south traffic. This makes the left turn for southbound traffic transverse more roadway to clear the intersection. In most cases protected by the

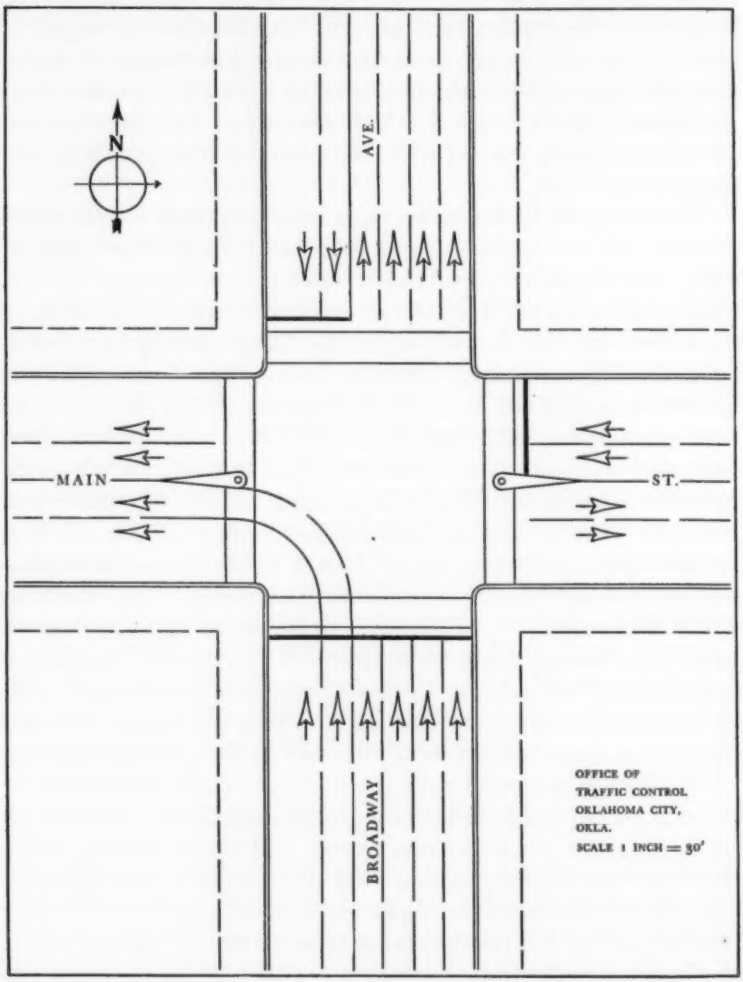


FIGURE 3. Main and Broadway Terminal Points.

FIGURE 2. Oklahoma City's Mid-Block Pedestrian Crossing.

traffic signals on this turn, sometimes drivers had a tendency to lag on this movement and they were confronted by three lanes of one-way traffic moving northbound.

Since the origin point was not satisfactory, it was decided to start the unbalanced two-way street one block north at the north side of Main Street. (Figure 3.) Where good alignment of the roadway was already established—extending this one block to the south, one-way north to Main Street—better circulation in this one block was produced by creating a counter-clockwise movement. It was found after this change was made that at this origin point of the unbalanced two-way street at Main and Broadway, the capacity of the intersection was sufficient not only to carry the present volume but to accommodate any anticipated future increase.

This unbalanced two-way street was established at the same time the new one-way streets were installed in 1955. It was decided to use a six-inch red off-center line, with reflectorized pedestal signs at each end of the blocks, beginning at Main Street and ending at N.W. 16th Street. This was necessary on a temporary basis to prevent vehicular conflict when the reduction of three lanes to two lanes and two lanes to one lane (in the opposite direction) created a potential source of conflict. After approximately four months of this installation, the pedestal signs were removed, only the off-center red line now being used, with good results. The public has reacted favorably to this permanent off-center movement.

Special emphasis was put on how to drive on the unbalanced two-way street. The change-over to this unbalanced flow system was made without serious trouble being encountered. This holds true today as the accident analysis taken over a two-year period indicates a decrease of 17.25 percent over the old two-way system.

NORTH BROADWAY—UNBALANCED TWO-WAY—1¼ MILES

Time	*Intersection Accidents*	*Non-Intersection Accidents*	*Total*
May 31, 1954 to May 31, 1955	259	83	342
May 31, 1955 to May 31, 1956	216	67	283

Note: Predominant causes were following too close and failure to yield the right of way. Only five accidents were attributed to driving in the wrong lane and these were classed as minor.

In answer to the question as to whether or not the unbalanced flow invariably increased the usable capacity of the street, this was determined by direction counts which were made during the peak hours, approximately one year after the change in the two-way system.

PEAK HOUR DIRECTIONAL COUNTS SHOWING UNBALANCE AND RATIO FOR MID-DAY

Time	*Old Two-Way System*		*Unbalanced Two-Way*		*Percent Change Over 1953*		*Percent Change Over 1953 Total Volume*
	North	*South*	*North*	*South*	*North*	*South*	
8 to 9 A.M. and 5 to 6 P.M.	1,390	1,885	2,539	1,395	+82.5	−25.9	+20.1
Other 6 hrs. 7 to 8 and 9 to 12 A.M. 12 to 5 and 6 to 7 P.M.	3,793	5,164	5,281	3,145	+39.2	−39	−6.9

Note: Since additional lanes were assigned to the major direction of flow northbound the above count indicates a 20.1 percent increase over the old system with the decrease of 6.9 percent for southbound traffic accounted for by diverting to the one-way southbound street directly to the west.

The experience and data obtained on speed and delay checks during the operation of this unbalanced two-way street at the peak and off-peak hours indicated improved progression for northbound traffic.

	Northbound	*Southbound*
MID-DAY	19.5 M.P.H.	10 M.P.H.
P.M. RUSH	18.1 M.P.H.	12 M.P.H.

An important advantage of this unbalanced two-way street is the facility of movement obtained particularly during the peak hours. This is accounted for by several factors.

(a) Increased lane movements.
(b) Improved traffic signal timing favoring direction movement northbound.

The workability of this unbalanced two-way street in conjunction with the new one-way street system has created inquiries from local

and outside interests. Our conclusion from studies and observations is that the unbalanced flow invariably increases the usable capacity of the street, and from our own experience, that the terminals of this unbalanced system must have adequate capacity to take care of the volume this movement may be expected to create.

As a partial answer to meeting the extreme congestion arising from the mass movement of traffic in one direction, with light movement in the opposite direction, and with proper terminal points established in connection with our one-way streets, we recommend the use of off-center lane movement.

Though this system has been widely accepted by the public for its improvement of traffic movement, the other stages should be carried out to complete the entire program where it is expanded to outlying areas of the city. The completed system will require wider pavement on primary streets, widening the approaches and exits at principal intersections, numerous new traffic signal installations and additional modern roadway lighting.

Whether the entire proposed street transportation system is realized will depend largely upon the attitude of the citizens of Oklahoma City. If they demonstrate the necessary courage, unselfishness, and willingness to provide funds, the entire recommended program for such improvements can be accomplished.

Highway Transportation Problems: Organization and Evaluation

FLETCHER N. PLATT

Mr. Platt is Manager of the Traffic Safety and Highway Improvement Department of the Ford Motor Company. This department was established in March, 1954. For the preceding four years, Mr. Platt was in product planning and sales activities of the Ford company. He is a registered professional engineer in Pennsylvania. From 1945 to 1950, Mr. Platt was Chief Design Engineer for the Ordnance Development Division of Rheem Manufacturing Company. He is not a traffic, highway, or safety engineer, but has experience in the analysis of complex problems. His contacts with many of the experts in the traffic and highway professions resulted in the development of this paper.

HIGHWAY and traffic specialists are well aware of the complex nature of highway transportation and appreciate the difficulty of explaining inter-relationships of its organization and problems to the uninitiated. This report, developed for just such a purpose, proposes to:

1. Define the components and inter-relationships of the highway transportation system, its organization and activities.
2. Define and evaluate the major traffic problems.
3. Establish the areas of responsibility for the reduction of casualties.
4. Estimate the reduction in casualties that is possible in the next decade.

Because of highway transportation's complex nature, it can be analyzed in many ways. One might attempt to compare it with other systems. However, it cannot for several reasons be studied on the same basis as rail and air transportation systems. These large privately owned and operated systems are controlled almost entirely by federal legislation. On the other hand, about ninety percent of the vehicles on the highways are individually owned and operated; and more than 35,000 governmental agencies have, in some degree,

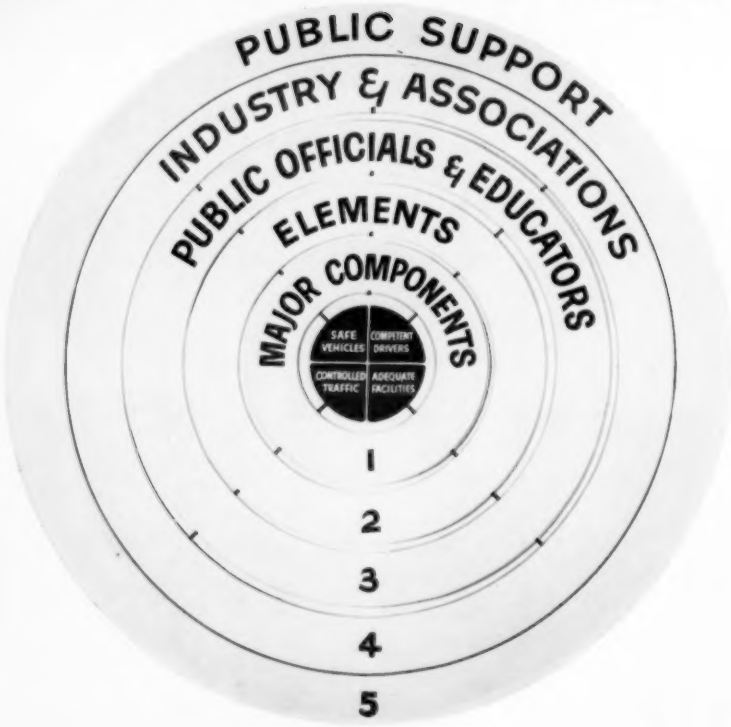


FIGURE 1.

FIGURE 2.

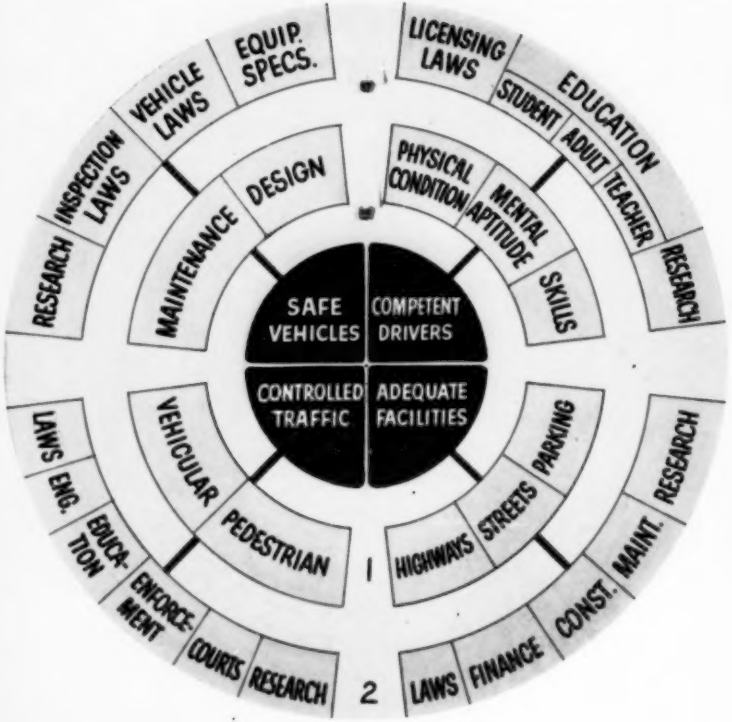


FIGURE 3.

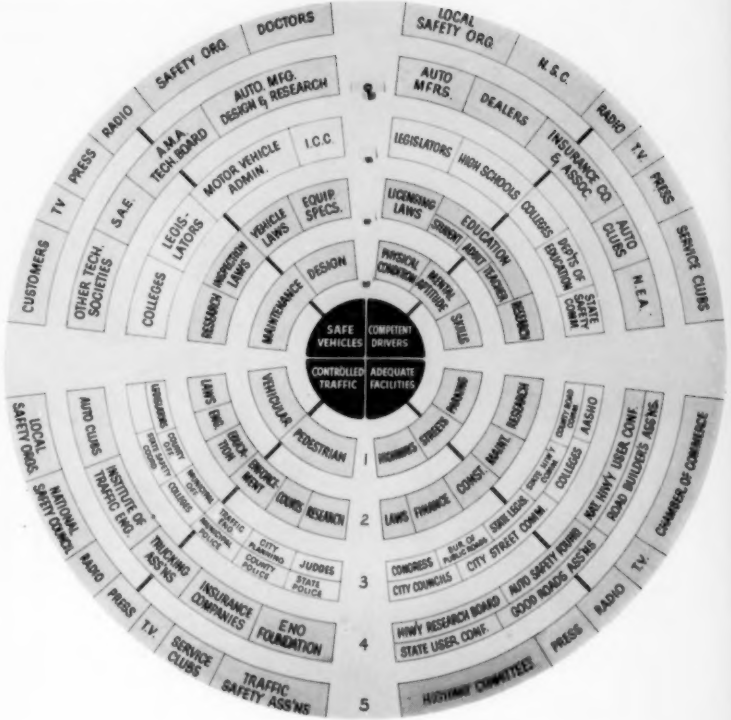


FIGURE 4.

control of the highway transportation system. These agencies do not operate uniformly or consistently.

The operators of rail and air transportation equipment are required by law to be trained, highly skilled and licensed, to meet rigid physical and mental standards. Most of the 76 million drivers would not meet such high qualifications. Rail and air equipment must be maintained at a high standard required by law; at present only fourteen states have requirements for motor vehicle inspection.

Surveys and voluntary safety checks indicate there are many cars on the road in unsafe operating condition and at least ten percent of the collisions involve faulty equipment.[1] Highway transportation has grown without central co-ordinated control or planning for the driver, the vehicle or the roadbed. It has expanded more rapidly than anticipated, and the problems are now of national concern. There are thousands of organizations, associations and clubs taking various parts in diverse activities relating to the problems.

Four Basic Targets for Efficient System

To establish and evaluate the relationships of various groups and organizations connected with highway transportation, a chart has been developed around four basic targets for an efficient system: safe vehicles; competent drivers; adequate facilities and controlled traffic.

The chart consists of five concentric circles, divided into four quadrants. Each band has a functional relationship to the four major components. (Figure 1.) The rings have been numbered from the center out.

1. Major Components
2. Elements
3. Public Officials and Educators
4. Industry and Associations
5. Public Support

Bands 1 and 2 surrounding the target section shown on Figure 2

[1] Of a total of 3,118 accidents reported on the Pennsylvania Turnpike, 430 (or 14 percent) vehicle failures were reported as a precipitating factor. Pennsylvania Turnpike Joint Safety Research Group Report, September 1954, p. 277.

The 1956 Vehicle Safety Check Program, sponsored by the National Safety Council and the Inter-Industry Highway Safety Committee, showed that one out of five cars inspected (voluntarily) had faulty brakes, lights or tires. Many had more than one deficiency.

contain the major components and elements of the four quadrants. These are the details that must be individually strengthened to improve the system's efficiency. Reading clockwise on band 1 from the lower right quadrant, the major components of adequate facilities include parking, streets and highways. Pedestrian and vehicle traffic must be controlled. Maintenance is equally as important as design when considering the safety of vehicles. Drivers' physical condition and mental aptitude as well as skills are related to driving ability.

The elements of highway system operation are shown on band 2. They include the legal, educational, construction and research phases of the problem. These elements must be improved and co-ordinated to benefit the total system. There is no single solution to so complex a problem and no one element is the key to the solution. At present, there are no scientific means of evaluating the individual elements or results of changes. Several official and unofficial organizations act as co-ordinating agencies for some important elements and components, but there is no system-wide co-ordination.

Public officials—motor vehicle administrators, police chiefs, judges, highway and traffic engineers, planners, legislators—have the primary legal responsibility under statutes and ordinances for control of the highway transportation system (Figure 3). It is their responsibility to take direct action in this field. Private organizations have no legal authority or direct responsibility but are in the position of supporting official agencies.

Education in all areas of traffic and highway management has been handicapped because of relatively little financial support in relation to research and the dissemination of knowledge in this area. Educational institutions provide instruction in many fields including highway and traffic engineering, police administration, traffic court procedure, safety engineering, city planning and others. Few universities are equipped to provide this type of training on a substantial scale. Frequently, their activities are supported by private grants. One encouraging recent development was the establishment within a land grant college of a traffic safety center financed by a legislative budget.

Additional research is desperately needed in the areas of accident cause, human engineering, and physical requirements for drivers.

Only recently a research project has been established to assist the automotive engineer in the design for crash injury reduction. The program at Cornell Medical College is the first major effort to evaluate statistically the cause of automotive crash injuries.

Officials and educators require full support of the public in developing and operating highway transportation programs. Associations and public support groups require guidance and close co-operation between officials and these groups. Bands 4 and 5 in Figure 4 show some representative organizations concerned with the different phases of the problem. Many organizations have special interests—all have separate viewpoints.

The press, radio and TV carry the burden of keeping the public informed of official actions. Traffic safety and highway organizations supported by private funds also help perform this service, but because these organizations are primarily supported by voluntary contributions they often do not have sufficient resources. Unfortunately many important activities relating to traffic improvement are organized and operate on a voluntary basis when their functions should be co-ordinated. Only recently the Congress authorized the Bureau of Public Roads to study the driver as well as the highway. Few states have a state traffic safety commission operated with public funds.

Industry and business to some extent influence the highway transportation system in several ways: Educational advertising to obtain public understanding and support; participation in and contribution to public support groups; memberships in associations; direct support of official programs; financial support of educational and research activities.

Often, industry is expected to carry the entire financial burden of public support groups without contributions from business and the public. It is important that a well-organized program be developed by a responsible agency before public support is requested; too often, support is asked for a nebulous or non-existent program.

Figure 4 clearly illustrates the complexity and extent of public concern in the highway system, its many components, and activities of controlling groups. Obviously, its organization and programs are difficult to understand and explain. Consequently, lack of co-ordination in public efforts results.

A detailed list of typical official and public support groups currently most active is shown in Table I, "National Organizations—Direct and Co-ordinating Activities." National organizations with an economic interest in traffic safety and highways are shown in Table II. Many groups listed in Table II are supported by one or more of the organizations in Table I. These organizations are the backbone of groups operating at the national level.

Table I

ALPHABETICAL LIST OF TYPICAL NATIONAL ORGANIZATIONS
DIRECT AND CO-ORDINATING ACTIVITIES

Safety and Highway Organizations

Automotive Safety Foundation
Inter-Industry Highway Safety Committee
National Highway Users Conference, Inc.
National Safety Council
President's Highway Advisory Committee
President's Action Committee for Traffic Safety

Public Officials Organizations

American Association of Motor Vehicle Administrators
The American Association of State Highway Officials
American Municipal League
International Association of Chiefs of Police
National Association of County Officials
National Association of Township-Officials

Co-ordinating Organizations

Association of Toll Road Authorities
The Bureau of Public Roads
Highway Research Board
International Road Federation
Commission on Safety Education
Committee for Fleet Supervisory Training
Committee on Traffic Law Enforcement
Committee on Traffic Training
Committee on Uniform Laws and Ordinances
Committee on Uniform Traffic Accident Statistics

Colleges, Universities and Foundations

Brookings Institution
University of California
Cornell Aero Laboratory
Cornell Medical College

The Eno Foundation
Harvard School of Public Health
Iowa State College
University of Michigan
Michigan State University
New York University
Northwestern University
Pennsylvania State College
Purdue University
University of Tennessee
Wayne University
Yale University

Professional Organizations

American Bar Association
American Society of Civil Engineers
American Society of Safety Engineers
Institute of Traffic Engineers
Society of Automotive Engineers

Table II

TYPICAL NATIONAL ORGANIZATIONS—WITH ECONOMIC INTEREST IN TRAFFIC SAFETY AND HIGHWAY IMPROVEMENT

Automotive and Allied Associations

American Petroleum Institute
Automobile Manufacturers Association
Automotive Parts Manufacturers Association
Finance Companies and Banks
Ford Motor Company
National Association of Independent Tire Dealers
National Automobile Dealers Association
National Rubber Bureau
Rubber Manufacturers Association
Steel Industry (Automotive and Highways)
Truck Body and Equipment Association

Insurance Associations

Association of Casualty and Surety Companies
National Association of Automotive Mutual Insurance Companies
National Association of Independent Insurers
National Association of Insurance Agents

Highway Construction and Maintenance Groups

American Road Builders Association
Asphalt Institute

Associated General Contractors
Calcium Chloride Institute
National Sand and Gravel Association
National Slag Association
Natural Rubber Bureau
The OxyChloride Cement Association
Portland Cement Association

Users Organizations

American Automobile Association
American Bakers Association
American Bottlers of Carbonated Beverages
American Transit Association
American Trucking Associations Inc.
Association of Ice Cream Manufacturers
Chamber of Commerce of the United States
Milk Industry Foundation
National Association of Motor Bus Operators
National Grange
National Rural Letter Carriers Association
Private Motor Truck Owners Inc.
Transportation Association of America
United Fresh Fruit and Vegetable Association

Defining the Problems

The highway transportation system has been a major factor in this country's increasing standard of living. Nevertheless, when measured in terms of accidents and congestion, the efficiency of the system has been low, and improvements have lagged far behind their importance. The problems must be defined, evaluated, and appropriate consideration given to efficacious corrective methods.

The basic measure of the problem is congestion, collisions and casualties. Congestion can be the result of any one or all of the following:

1. Slow moving or stalled vehicles
2. Incompetent drivers
3. Inadequate facilities
4. Incomplete traffic control
5. Accidents

Congestion costs highway users billions of dollars annually. Commercial vehicle operating costs due to congestion amount to hundreds of thousands of man hours lost and greatly increased operating expense. The economic loss in wasted time of the average motorist is indeterminate, but extremely high.

It is generally agreed that inadequate highways, streets, and parking facilities have been the major cause of congestion. The best drivers cannot reduce congestion when the number of vehicles far exceeds the capacity of a roadway. The 1956 Federal Highway and Revenue Act promises some progress in the next fifteen years in improved facilities. Our next responsibility will be to increase the standards of driving and traffic control to further reduce congestion.

City planners must lay out the rebuilding of many areas and give important consideration to traffic and parking when planning new developments. Congestion in cities is a local problem and must be solved locally. Many urban areas have found ways of improving their traffic problems, and these methods are frequently applicable to many cities.

For years we have so voluminously discussed the degree of accident-reduction obtainable through engineering, education, enforcement, etc., that our hopeful estimates sometimes exceed 100 percent. This shows the lack of a reasonable framework within which all recognized factors may work in logical relationship with each other.

If such a formula can be developed and improved over a period of years, it may well serve many useful purposes. By adjusting the values of various components, it should be possible to obtain a clearer picture of what might be possible. If some values are rated too high, the formula may help to make this apparent.

Developing a Formula

Admittedly the creation of such a formula must at the outset be highly theoretical, but this is typical experience in developing formulas. Also, there will be many unknowns to which arbitrary values must be assigned. It is certain that there will be a wide range in degrees of agreement and disagreement regarding these arbitrary values by readers of this article. But healthy debate regarding the

values should not detract from the need for such a formula and the necessity of plotting various lines of reasoning in mathematical form.

Values given to the unknowns are strictly those of the author. The best that can be said for them is that they represent considerable thought and were not selected without a good deal of matching with collateral known factors.

As in any quality control program, traffic events or situations, including collisions and casualties, occur according to some law of probability. This is not to say that the odds cannot be altered. On the contrary, the favorable odds are with the careful driver, the motorist on the safely designed highway, the car in safe condition for driving. However, at any given time, the odds can be determined for a certain number of traffic situations to occur that can lead to collisions and casualties.

To explain the formula, it might be over-simplified by stating:

The highway environment has many variables. The driver sees groups of these variables as situations. Some of the situations require decisions. Drivers can be expected to make some errors of judgment. Some errors will cause near-accidents; others will cause accidents. Some will cause only property damage. A few will involve injuries and some fatalities.

What are the chance situations that each driver must see and consider on the highway? What clues does he get visually and orally that require a judgment to be made? Many of these situations are almost continuous, such as the position, velocity, and acceleration of all cars in close proximity to the driver. Evaluation of the road surface for irregularities, obstacles, and lane markings is also continuous. The driver must continuously scan the roadway ahead for possible hazards: pedestrians, animals and other objects in the driving path; the route, scenery, and passengers—any of these may cause distraction that affects the driver's judgment.

Traffic Situations Require Alert Drivers

As the motorist drives down a street or highway he sees ahead of him a wide variety of situations and combinations. These vary from an object on the pavement to a car or a pedestrian about to move in front of him. In minor situations his adjustment in driving is auto-

matic and requires no conscious or complicated decision, though he must at least evaluate and discard them. But even a combination of minor situations may require a decision as to what to do. Pulling left to avoid an object in the road may be fatal if a car behind is about to pass.

Thus in driving a mile on city streets, about fifteen blocks, an alert driver may well note twenty situations per block or 300 to the mile. For example, every parked car can hide a pedestrian, or threaten to pull out—five to a block might need to be checked. Of cars approaching almost head on, five in a block might need to be checked lest they move over to turn in front of one's car. A car passing on the right or left has to be watched—possibly one per block. At each intersection, with sixty-two legal conflicting movements, enough could develop to account for the remaining nine situations necessary to reach the total of twenty per block or 300 per mile.

In driving a mile in the country an alert driver would spot such situations as the following:

1. Intersections or driveways, potential spots from which someone could dash out in front of an oncoming car, several per mile.

2. Each oncoming car—which could make a left turn suddenly in front of one—say 25 per mile.

3. Each car approaching from the rear which may try to pass unsafely.

4. A car or pedestrian on the shoulder, that may move out in front of a driver—perhaps several to a mile.

This listing does not include signs, signals and markings which must be read, understood and in some cases acted upon. Nor does it include physical items such as ice spots, dangerous bumps in the road, glare, construction barricades or numerous other hazards.

These situations on streets and highways over which the vast majority of vehicle miles are driven could reasonably be expected to produce 100 situations per mile in the country and 300 per mile in the city—an average of 200 per mile country-wide.

They represent the most common driving situations, not an average which would include great mileage of desert highways, lightly traveled back roads, or sparsely settled residential areas.

Driving a car is somewhat like reading a book. It takes about as much concentration, and eyes are as important in one as in the other.

As we read it is not difficult to notice a misspelled word. This might be compared to the selection of hazards on the highways. Reading at a rate of 200 words per minute, a reader has approximately the same visual activity as driving at 30 MPH in traffic.

Most situations are noted, evaluated, and discarded by the driver's mind. It is estimated that for every ten situations the driver will make one decision affecting his position, his speed, or signaling to another driver or pedestrian. These are the three primary variables a driver can control. As a good driver, he may make twenty decisions per mile. He will undoubtedly make some errors, minor or critical.

It is assumed that he will average one mistake for each forty decisions (a 97½ percent rating) or one error for each two miles he drives. Perhaps in present day driving errors occur far more frequently. A study of driving habits in relation to the frequency of errors would be valuable research information.

For each 250 driving errors, hazards or other variables may be so located in space and time, as to create a near-collision.

Statistically, about 17,000,000 drivers were involved in 9,900,000 collisions in 1955, or one for every 61,000 miles driven.[2] In other words, if the estimate for near-collisions is right, one collision occurred for each 128 near-ones. The odds of injuries and fatalities are also based on National Safety Council data. Insurance companies rely on statistics to develop their rates and it is logical to establish this formula to understand the factors and relationships that lead to fatalities.

THE ODDS OF TRAFFIC SITUATIONS

1956

Situations (Driver Observations)	200 per mile
Decisions	20 per mile
Errors	1 per two miles
Near-Collisions	1 per 500 miles
Collisions	1 per 61,000 miles*
Injuries	1 per 430,000 miles*
Fatalities	1 per 16,000,000 miles*

2 National Safety Council, *Accident Facts 1956*, p. 55.

* National Safety Council, *Accident Facts 1956* (1955 data).

Ratio of Number of Situations to Decisions to Near-Collisions to Collisions to Injuries to Deaths

1 situation for every 26.4 feet (200 per mile)
(average between 300 per mile in city and 100 per mile on highway)
(1 situation every 53 feet on highway)
(1 situation every 17.5 feet on street)
1 decision in 10 situations
1 error in 40 decisions
1 near-collision in 250 errors
1 collision in 128 near-collisions
1 injury per 11 collisions
1 fatality per 300 collisions

Accident Facts 1956, p. 55
33,000 fatal accidents
880,000 injury "
9,000,000 P.D. "
9,900,000 total "

Ratio Applied to Driving 500 Miles

100,000 situations
10,000 decisions
250 errors
1 near-collision

Ratio Applied to Driving 100,000 Miles (10 years)

20,000,000 situations	200 per mile
2,000,000 decisions	20 per mile
50,000 errors	1 in 2 miles
200 near collisions	1 in 500 miles
1.56 collisions	1 in 61,000 miles

A Target for Reducing Traffic Casualties

What must be done to change the odds to reduce traffic casualties? (Figure 5.)

By improving highway design and increasing traffic control, the number of situations and consequently the number of decisions that the driver must make can be reduced. As these changes are made, however, they affect the odds of each succeeding event.

Driver errors can be reduced by improving driver licensing laws, raising the average driving ability by eliminating the incompetent drivers, adoption of uniform laws, driver education, better enforcement and improved traffic courts. These will change the odds by reducing near-collisions, collisions, and casualties. Many state and

municipal laws must be enacted or amended to effect these improvements.

As the center of the target is approached, corrective action has a more direct effect on casualty reduction. Improvements in vehicle controls, better visibility, and increased reliability of vehicle com-

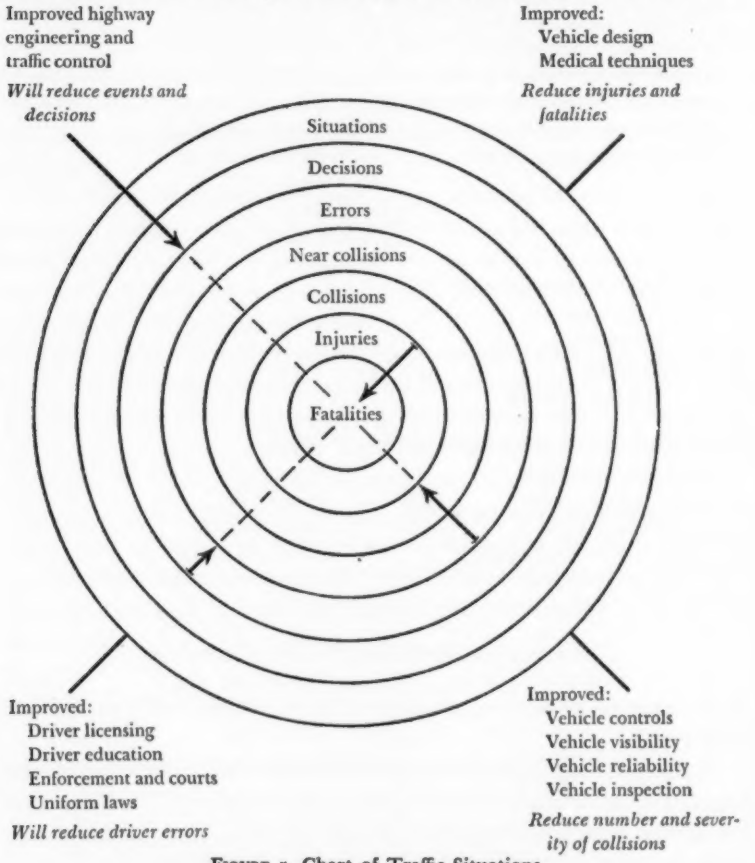


FIGURE 5. Chart of Traffic Situations.

ponents such as brakes and tires, have contributed to the reduction and severity of collisions. A vehicle inspection system can reduce the possibility of mechanical failures. The maintenance of equipment is as important as vehicle design in reducing collisions.

The principal objective of traffic safety is better driving and the

reduction of casualties. Saving lives and minimizing injuries must have top priority. The direct approach to this objective is to design the vehicle to protect the occupants in event of a collision. With the occupants properly packaged, injuries and fatalities can be reduced appreciably. About 72 percent of occupant-fatalities occur under reported traveling speeds of 60 MPH.[3] It is in this large segment of the casualties when the passenger compartment remains intact, that the greatest casualty reduction can be realized by packaging. Recent improvements in vehicle design for crash injury reduction have been made, and reports indicate that these features are materially reducing casualties.

When all cars are equipped with proved safety measures and devices, major casualty reductions will be realized. If the number of accidents remains the same, the degree of severity may contribute to lower casualties and fewer fatalities.

Medical techniques are continually improving. Better first-aid at the scene of accidents, new diagnostic techniques and improved emergency room management will further reduce fatalities of traffic trauma. Recent medical meetings have considered the responsibilities of the doctor in relation to traffic safety.[4]

An attempt has been made to evaluate the relative importance of various factors relating to traffic casualties and to estimate possible improvements. Refinement of the method by research and statistical techniques would undoubtedly modify this first approximation. Although these estimates are controversial, they serve to demonstrate the importance of the many factors involved.

Reducing Traffic Situations by Highway Design

Modern highway design can eliminate a tremendous number of situations. For example:

1. A widely divided highway.
2. Grade separations.

[3] National Safety Council, *Accident Facts 1956*, page 52.

[4] American Medical Association Annual Meeting, June 11–15, 1956, Symposium on Traffic Accidents.
American Medical Association—Congress on Industrial Health, January 22–23, 1956.
Harvey Cushing Society (Neurosurgeons) 24th Annual Meeting, April 16–18, 1956.
"Medical Aspects of Traffic Accidents"—Proceedings of 1955 Montreal Conference, Canadian Traffic Safety Conference.

3. Limited access.
4. Curves and grades.
5. No pedestrians.
6. Reduction in signs.
7. Few signals.
8. Wider lanes.

The fewer the "situations" that exist, the fewer decisions required, and the less the opportunity for errors. All are important contributions to improved driving.

Reduced Driver Errors

The motorist who has received excellent driver training can be expected to make fewer errors than the untrained driver. Stiffer driver license examinations will keep off the road drivers who can be expected to commit more errors than the average.

Enforcement action by the police—backed up by the courts—can reduce the number of violations. Since the driver in the act of committing a violation is more likely to make an error, this will reduce error.

Suspending more licenses will take off the road more error-prone drivers, thus helping to reduce the number of total errors.

The increased pressure against bad driving can be expected to keep drivers more alert. They will be more likely to drive as well as they know how, and thus make fewer errors than if they were not paying attention.

Car design improvements can help the driver to make fewer errors, eliminate some decisions and help protect him from the consequences of his error when it produces a collision. Better headlights and greater glass area help the driver see the situation sooner and more clearly. Automatic headlight dimmers remove the necessity for manual dimming—an error which can blind an oncoming driver. Interior design can reduce the injury resulting from a collision.

Based on the author's estimates, this proposal indicates that if accepted and predictable techniques are put into effect in the next ten years, it will be possible to reduce:

Fatalities of:	
Vehicle occupants to	50% of the present
Pedestrians to	71% " " "
Injuries of:	
Vehicle occupants to	59% " " "
Pedestrians to	83% " " "
Collisions to	87% " " "

On the basis of 1955 estimates, this would mean an annual saving of 15,700 lives, 517,000 injuries and 1,287,000 collisions. To accomplish this, it will require the constant effort of many groups and a minimum of four to five times the financial support that traffic safety interests now receive.

Table III presents the estimate of changes in highway casualties by establishing possible percent variations of related events. (It would be desirable to further refine these estimates by statistical evaluation and weighting of each factor in relation to its appraised importance.)

The number of highway situations has been divided into three divisions: fixed, transient, and environmental. Estimates of the ratio of 1966 to 1956 situations in each of the three categories are made. A total ratio is then computed by multiplication. This same method is used in each of the succeeding events and in each one is obtained by multiplying by the ratio of the preceding event.

By this method every important factor is accounted for in proper sequence. No attempt has been made to weight the various events or their components. It would be interesting to apply certain statistical techniques to this plan or consider the possible use of linear programming. However, this presentation has made no attempt to evaluate these possibilities.

This analysis has defined the components of the highway transportation system.

Traffic problems have been classified as congestion, collisions, and casualties, with special emphasis given to the collisions and casualties.

A chart presents the relationship of highway events and indicates areas of responsibility for these situations to certain groups.

Estimates have been made of the possible improvement in the number of traffic casualties within the next decade.

This analysis suggests the importance of the following:

A need for developing sound statistical methods to evaluate the many programs relating to traffic safety.

A need to develop a broad public education program in highway transportation to effect the needed improvements in the system.

Traffic casualties can be reduced an appreciable amount by the use of accepted practices in the many elements of the system.

ESTIMATE OF CHANGES IN HIGHWAY EVENTS BY 1966

	Ratio $\frac{1966}{1956}$ Situations	
HIGHWAY SITUATIONS PER MILE		
1. Fixed Situations Road Design Road Condition Traffic Controls Parked Vehicles	.90	
2. Transient Situations Vehicles (Registrations up to 30 percent) Pedestrians (Population up to 20 percent)	1.25	
3. Environmental Situations Weather Road Surface Miscellaneous Hazards	1.00	
Ratio of Highway Situations 1966 to 1956 .90 x 1.25 x 1.00		1.125

	Ratio $\frac{1966}{1956}$ Decisions	
DRIVER DECISIONS, per driver per mile		
1. Affected by Engineering Highway Engineering Traffic Engineering	.90	
2. Affected by Education Driver (the other driver) Pedestrian	.90	
3. Number of Highway Situations (from above)	1.125	
Ratio of Driver Decisions 1966 to 1956 .90 x .90 x 1.125		.91

	Ratio $\frac{1966}{1956}$ Driver Errors	
DRIVER ERRORS, per driver per mile		
1. Driver Licensing Laws (Eliminate 4 percent unqualified)	.90	
2. Upgrade driver Education Law Enforcement	.95	
3. Uniform Rules of the Road	.95	
4. Driver Decisions (from above)	.91	
Ratio of Driver Errors 1966 to 1956 .90 x .95 x .95 x .91		.74

	Ratio $\frac{1956}{1966}$ Near-Collisions	
NEAR-COLLISIONS, per vehicle per mile Same ratio as driver errors		.74

	Ratic $\frac{1966}{1956}$ Collisions	
COLLISIONS, per vehicle per mile		
1. Vehicle Design Visibility Lights Steering, acceleration and braking	.94	
2. Vehicle Maintenance Mandatory periodic inspection	.95	
3. Near-Collisions (from above)	.74	
Rate of Collisions per vehicle per mile 1966 to 1956 .94 x .95 x .74 (Collision rate can decrease 1/3)		.66
COLLISIONS, total per year		
1. Collisions per vehicle per mile	.66	
2. Vehicle miles per year Vehicle Registrations 30 percent Vehicle Mileage 2 percent	1.32	
Ratio of total collisions 1966 to 1956 .66 x 1.32		.87

	Ratio $\frac{1966}{1956}$	Collisions
CASUALTIES, total		
Occupants		
1. Improved Vehicle Design (interior)	.85	
2. Occupant Restraint	.80	
3. Collisions (from above)	.87	
Ratio of Occupant Casualties		
.85 x .80 x .87		.59
Pedestrians		
1. Vehicle Design (exterior)	.95	
2. Collisions (from above)	.87	
Ratio of Pedestrian Casualties		
.95 x .87		.83
FATALITIES, total		
1. Casualties		
Occupants	.59	
Pedestrians	.83	
2. Improved Medical Techniques	.85	
.59 x .85 = Total Change in Occupant Fatalities		.50
.83 x .85 = Total Change in Pedestrian Fatalities		.71

The Oakland Signal Formula

ERLING HORN

Mr. Horn is Associate Engineer, Division of Traffic Engineering, for the City of Oakland, California. He has been engaged in traffic engineering work since early 1939, except for six years during World War II. Mr. Horn holds a Master's degree in electrical engineering and was employed as Junior Engineer with the Western Electric Company. Later he changed his field to civil engineering, starting out with the Oakland Street and Engineering Department in 1935.

THE following article to supplement some of the thinking in the field of traffic signal warrants simplifies somewhat, but does not propose to modify or add to, the reasoning behind the Detroit Signal formula (*Traffic Quarterly*, October 1951, page 398). Perhaps the Oakland formula adheres more closely to the factors contained in the warrants listed in the 1948 Manual on Uniform Traffic Control Devices, and its revision in 1954.

The change produced by the 1954 revision is appreciable, placing a stiffer requirement on several of the warrants by inserting the words "for each of" in place of "average." To determine the numerical effect of this revision a traffic volume profile plotted against time of day for a typical city street was made.

Referring to the traffic volume curve in Figure 1, it can be seen that the substitution of the words "for each of eight hours" for "average of any eight hours" means an upward revision of 26 percent in the volume requirement in the following case: $\frac{7{\cdot}7-5{\cdot}7}{7{\cdot}7} = 26\%$.

The example chosen is a mixed residential–light commercial street carrying a volume of 10,000 vehicles per twenty-four-hour period. This particular city arterial (Bond Street) is now undergoing improvement and will probably develop potential traffic signal situations in the future.

Actually it has been found practicable to measure the twenty-four-hour volume and divide by two, to obtain the maximum eight-hour volume. The average of the greatest eight hours is then 50

percent divided by eight, or 6.3 percent of the twenty-four-hour volume. It is convenient to use this average figure, for example, in translating the minor street requirement of 175 vehicles an hour approaching the intersection into its twenty-four-hour equivalent of 2,800 vehicles (Vehicular Volume Warrant).

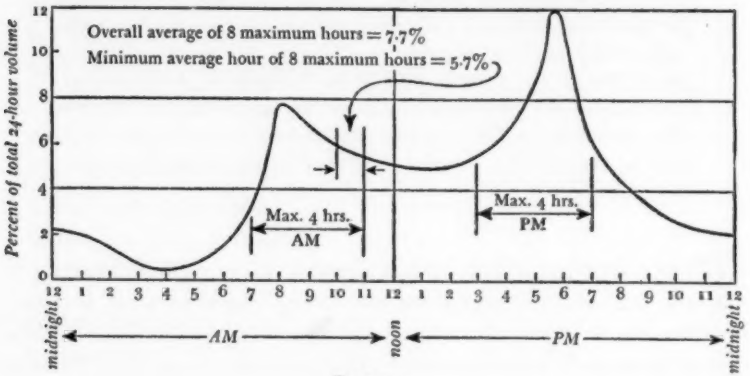


FIGURE 1.

Comments follow on each of the several warrants as used in the Oakland formula, with particular reference to the New York formula published in the July 1955 *Traffic Quarterly*.

I. Volume Rating

The reasoning behind basing the score on the product of V_m and V_c is agreed upon, with some reservations on the use of the K factor. The New York formula adopts a straight-line increase in K with increase of $\frac{V_m}{V_c}$ which operates to render the volume rating V independent of V_m when values of $\frac{V_m}{V_c}$ vary between 4 and 8. It is believed that a minor street volume of 250 vehicles an hour has a more difficult time to cross a V_m of 2,000 an hour than it would a 1,000 per hour volume, and so merits a larger volume score. However, the New York formula makes K increase with V_m and so nullifies the effect of changes in V_m on the score. This is shown in chart form in Figure 2.

In Figure 2 the straight-line values of K (NY formula) are shown plotted along a more rational value of K (curve just below K_{NY}).

$\frac{V_M}{V_C}$	4 or less	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8 or more
$K_{(NY)}$	1.00	1.13	1.25	1.38	1.50	1.63	1.75	1.88	2.00
$K_{(prop)}$	1.00	1.13	1.24	1.35	1.44	1.51	1.56	1.62	1.67

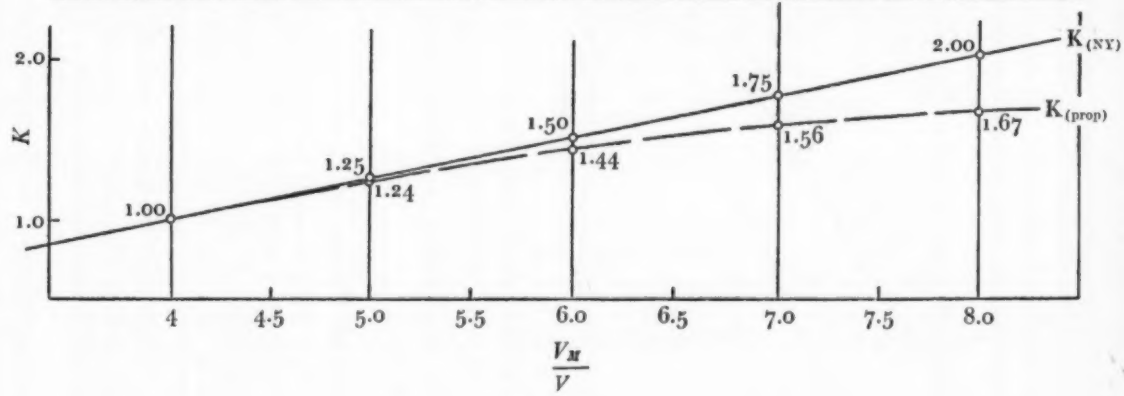


FIGURE 2.

This operates to increase slightly the volume score with an increase in V_m. The score may be obtained directly by using the nomograph

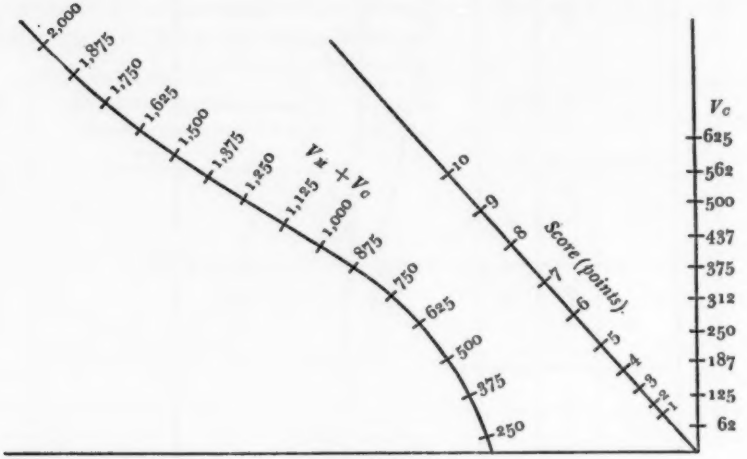


FIGURE 3.

shown just above the K chart (Figure 3) . The operation of obtaining $\frac{V_m V_e}{K \times 1{,}000}$ is performed directly by placing a straight edge on V_e and $(V_m + V_e)$ and reading the corresponding volume rating based on a scale of 10.

II. Pedestrian Rating

The New York formula here interposes a "width of street" factor, but neglects a minimum speed requirement of traffic on the main approaches. A suggested nomograph (Figure 4) gives a pedestrian rating on a basis of five points if all three conditions as listed in the M.U.T.C.D. are met. The twenty-four-hour volume for V_m is shown rather than the hourly volume in accordance with more common practice. Also note that provision is made for a reduction in rating where main approach speeds are less than 15 MPH.

III. Accident Rating

The factor "failure of other remedies" seems to be neglected in the New York formula as it is probably difficult to rationalize as a

numerical rating. The Oakland formula also neglects this factor but assigns values to the other two: (1) correctable collisions and (2) percentage of pedestrian and vehicle volume satisfaction. With reference to the latter warrant, the pedestrian requirement is probably more difficult to satisfy in most cases and, therefore, need only be considered.

Another proposed factor to consider in the accident warrant is

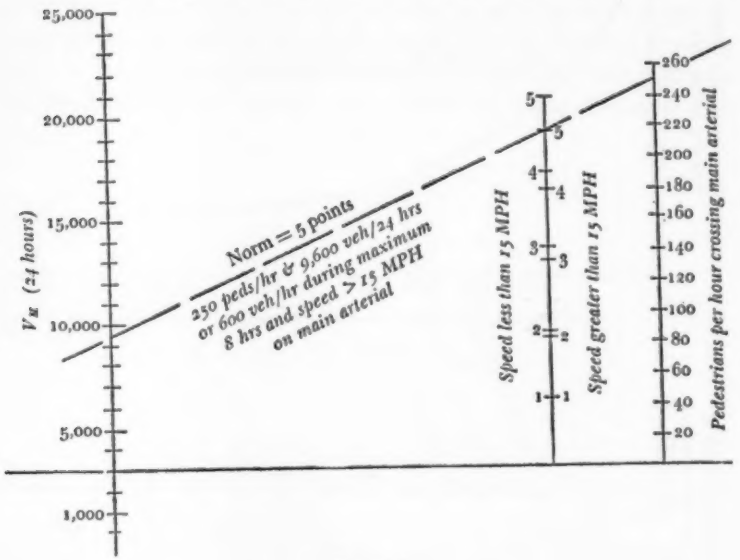


FIGURE 4.

the accident incidence or overall accident record, regardless of type, pertaining to the intersection. Those collisions "susceptible to correction by the installation of a traffic signal" should carry the most weight; but it is thought that the accident record in general, inclusive of all types, should also affect the accident rating. The "number of collisions per million vehicles entering" applies to an intersection in the same manner as the "number of collisions per million vehicle miles" applies to a section of highway.

In Figure 5, if the collision incidence (Y-axis) is plotted against volume (X-axis) for a great number of intersections, the curve shown might be obtained. Considering points along this curve as the nor-

mal "to be expected incidence" the intersection under study can then be compared, and the comparison (normal, half of normal, twice normal, etc.) entered on the chart (Figure 6) for the accident rating. This latter rating chart is so designed that "accident incidence" has much less impact on the accident rating than does either

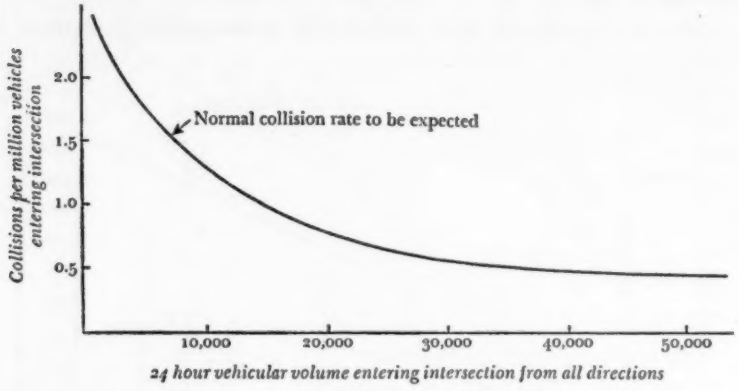


FIGURE 5.

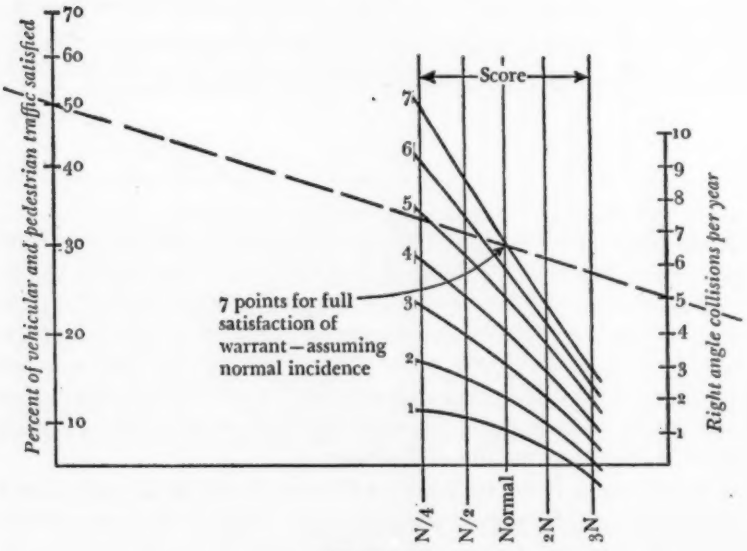


FIGURE 6.

of the other two factors—right angle collisions or percent of pedestrian and vehicle volume.

IV. Through-street (Interruption) Rating

The New York formula does not mention "Interruption" but uses the major street requirement of 750 vehicles an hour and speaks of gaps in traffic provided by adjacent traffic signals. It would appear that the factors given here should more properly appear in the progression warrant in which distance to the nearest existing signal is one of the main considerations. In any case, it is believed that the interruption warrant, or measure of desire of people and

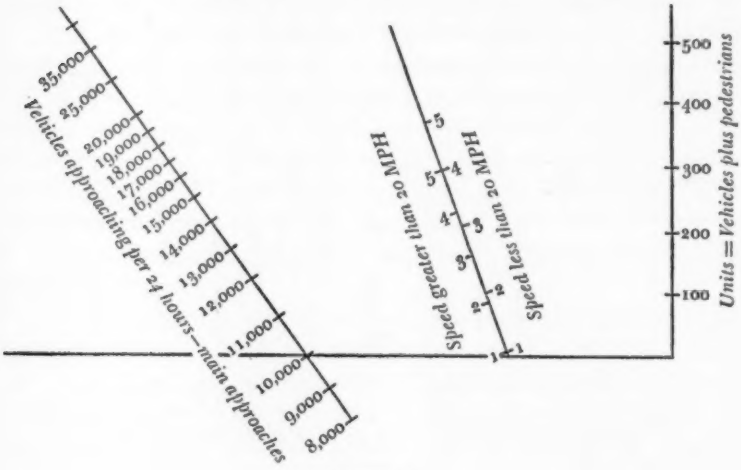


FIGURE 7.

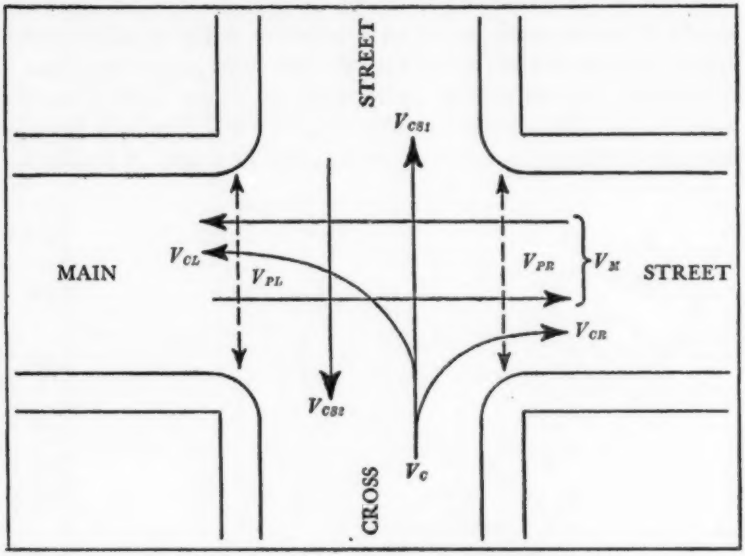
vehicles to interrupt a main traffic artery, should be evaluated in accordance with the M.U.T.C.D.

With reference to Figure 7, all three factors required by the warrant are entered to obtain the score: (1) number of units (pedestrians plus vehicles) desiring to cross; (2) speed of traffic stream crossed; (3) volume of main stream. Placing a straight edge on the values for items (1) and (3) the score is read in the appropriate speed column in the middle of the figure.

Figure 8 is an explanation of those movements used to determine the numerical value of (1) above. It will be noted that to affect the

score the movement must be entirely across the main arterial, or at least a portion thereof.

In the case of a "T" intersection, the interruption warrant then would include only those vehicles entering from the intersecting leg and making a left turn, thereby crossing one-half of the main



Units = Pedestrians crossing main street ($V_{PL} + V_{PR}$) plus vehicles crossing main street ($V_{CS1} + V_{CS2}$)

Do not include V_{CR} or V_{CL} (right or left turns from cross street to main street)

FIGURE 8.

street movement. In the figure this is labeled V_{CL} (left turns from the cross street).

In California a vehicle entering from the cross street and turning right does not have to wait for a green signal but may turn on the red signal (after stop). Therefore, no formal interruption of the main stream is required.

V. Progression Rating

The 900-foot distance between adjacent traffic signals is the half-cycle spacing ideal for a 50-second cycle signal system, assuming a

speed of 25 MPH is desired. For greater distances than 900 feet, two-way progression requires greater speeds; similarly, for lesser distances, the progressive speeds are slower, assuming cycle length constant at fifty seconds.

Practically speaking, the only variable on two-way streets is cycle length. Recent studies have demonstrated that motorists select and attempt to maintain a prevailing speed. Important secondary streets crossing a main arterial are fixed in position; therefore, it is the duty of the traffic engineer to select the cycle length applicable to fit the other two fixed conditions. Once that is selected, then subsequent signal locations are scored with reference as to how an existing progression may be affected by the installation of the new signal.

It is also assumed, if the main street is two-way, that either half-cycle or one-cycle offsets will be used, insofar as scoring is concerned. Actually the setting may be fractional to allow for inbound and outbound traffic peaks, thus penalizing one direction in favor of the heavy movement. However, these fractional settings usually occupy only a minor portion of the twenty-four hours, and for that reason need not enter into the progression score.

Here are some conditions which might apply to the proposed signal location:

1. Distance to nearest signal on either street—greater than 2,600 feet. *Answer:* No loss in progression score as the "platooning" effect of the nearest signal has entirely disappeared (*Traffic Engineers Handbook,* page 145). Therefore, maximum benefit insofar as restoration of the platooning of traffic is concerned can be expected.

2. Main Street one-way; cross street two-way. *Answer:* No loss in score insofar as the main street is concerned. Scored in accordance with two-way speed obtainable, considering minor street progression only. Compute total progression score, averaging scores obtained when considering each street separately.

3. Distance to nearest signal (both streets)—less than 2,600 feet; both streets two-way. *Answer:* Enter the half-cycle offset chart (Figure 9) with the cycle length used and the distance to obtain the two-way progressive speed. A suggested corresponding score chart is shown immediately below the figure.

If the distance and cycle length are such that the point is off the chart, divide the distance by two, thus in effect assuming full cycle

or simultaneous offset. Normally in an urban area, progressive speeds will not exceed 40 MPH.

The progression warrant (Oakland formula) is perhaps not too well founded on the M.U.T.C.D. It does, however, place a heavy

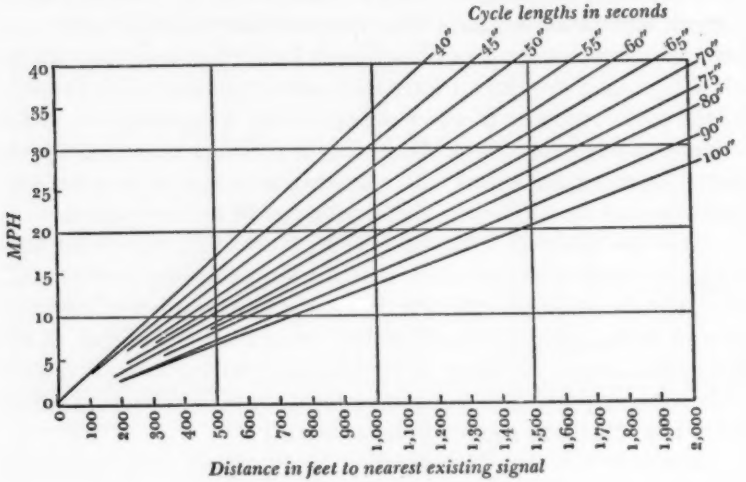


FIGURE 9.

value on maintenance of progressive speeds in the neighborhood of 25 MPH, and by the same token favors one-way operation in that fractional settings may be used.

The five warrants total thirty-two points maximum, broken down as follows:

Vehicular Volume	10
Pedestrian	5
Accident	7
Interruption	5
Progression	5

In conclusion, it can be said that only the five warrants as listed in the M.U.T.C.D. are scored, and with the exception of the progression warrant, only those factors to be met in the individual warrants are used in the Oakland formula to obtain a signal priority score.

Forecasting Festival Traffic During Jamestown's 350th Anniversary

RUDYARD B. GOODE AND ROBERT K. TURNER, JR.

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THE lower Peninsula of Tidewater Virginia is roughly defined by the Chesapeake Bay on the east, the York River on the north, the James River on the south and the Chickahominy River on the west. It is about thirty miles in length, has a mean width of five miles, and may be unromantically described as looking like a drumstick with one bite out of the middle.

Two counties, James City and York, comprise the western, rural part of the peninsula, and the cities of Hampton, Newport News, and Warwick occupy the eastern tip. The 1950 population of the area was slightly over 113,000.

The Lower Peninsula abounds in spots of historical interest. The institution of our culture, the heaviest single influence on our political ideology, and the military success which made possible our existence as an independent political entity can all be traced to the triangle formed by Jamestown, Williamsburg, and Yorktown. Within the confines of this triangle the colonial era was born, matured, and died.

Americans who seek inspiration from and information about the nation's past are attracted eventually to the Lower Peninsula; it has been the scene of several expositions to commemorate anniversaries of historical significance. In 1881 and again in 1931 a properly humble General O'Hara delivered up Cornwallis's sword at Yorktown. The settlement at Jamestown was celebrated in 1907 by an extensive centennial which lasted for seven months and attracted visitors and exhibitions from all over the world. Of a more per-

manent nature, the restoration of Williamsburg is an enduring tribute to the importance of the colonial period and of the men who made it great.

Plans of considerable magnitude are now being laid for the celebration in 1957 of the 350th anniversary of the settlement at Jamestown. Although this affair will be known as the Jamestown Festival, it will be composed of special functions and exhibitions in several parts of Virginia but principally in Jamestown, Yorktown, and Williamsburg. Both a Federal and a state commission are directing efforts toward the development of appropriate activities, and if the plans now contemplated are carried into execution the Ter-Centennial of 1907, which was no small undertaking, will seem by comparison like a Sunday school picnic. Indeed, in 1957 the economy of the entire state should be bolstered by the celebration, and it is probable that it will have a lasting effect on tourist trade, an important source of the state's income.

Traffic Study Requested

Early in its planning the state commission began to have qualms about the volumes of traffic which could be carried safely and expeditiously by the roads of the Lower Peninsula. The commission desired to make the Festival visitor's stay in Virginia as pleasant as possible and reasoned that his disposition would not be improved by traffic jams and crumpled fenders.

An extensive advertising campaign was contemplated to attract visitors not only to the Festival generally but also to specific events. The amount of traffic that could be handled was one of the limiting factors on the type and volume of advertising. How many cars would be on the road? Where could they park? What highway improvements would be needed? Should any new highways be built?

The commission turned to the highway department. The highway department faced difficulties too, since the commission's plans for specific locations and dates of certain events were still nebulous, and also because there was little precedent for making estimates that would be fundamental in solving the commission's problems.

How the department's traffic estimates for the Jamestown Festival were prepared may be of interest here. The method used was

simple. First an assessment of present traffic conditions in the Lower Peninsula was made. Then a normal projection to 1957 was made—that is, a projection which did not take into account the effect of the Festival. Finally, the normal projection was adjusted to reflect conditions that would obtain during the Festival. The adjustment was

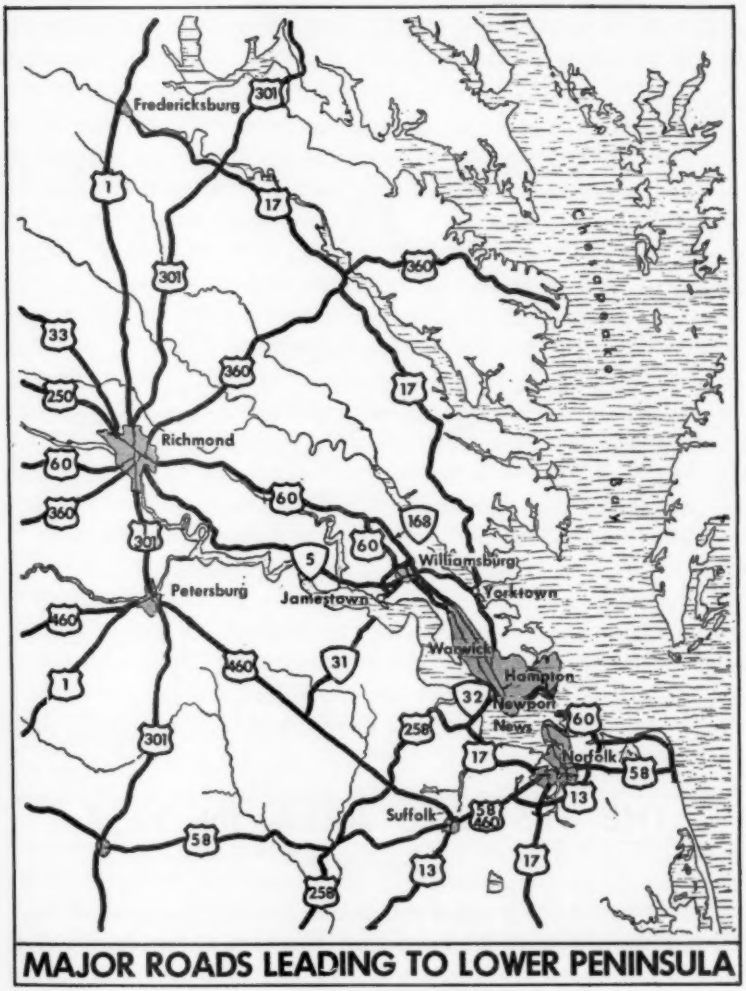


FIGURE 1.

based on the best data that could be gathered at the time and a fair measure of conjecture.

The System of Roads

Despite the natural barriers formed by the rivers and the many fingers of Chesapeake Bay and the James River which jut into the coastline both north and south of the Lower Peninsula, the area is

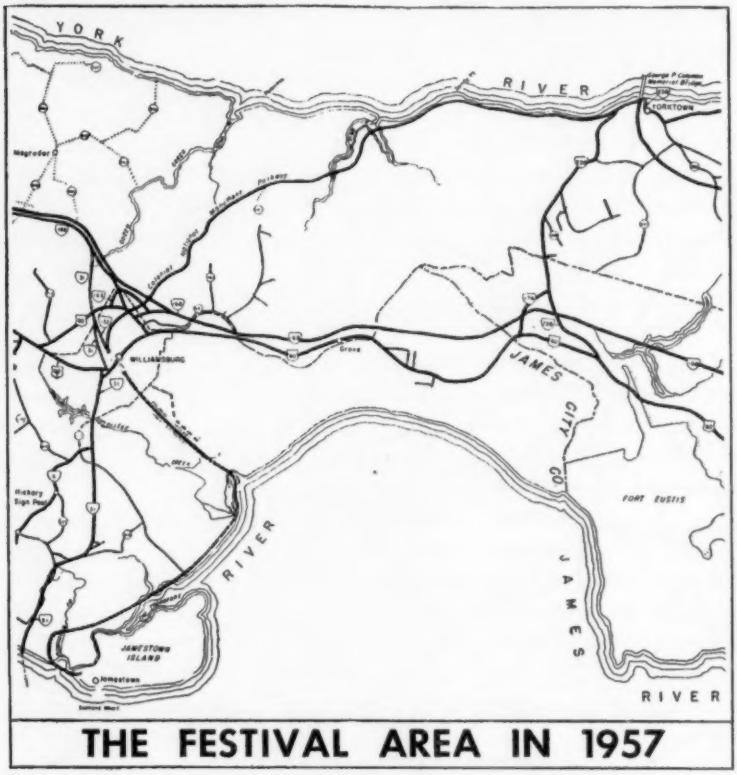


FIGURE 2.

well served with roads and the motorist has a high degree of flexibility in the choice of his route and direction of travel. (See Figure 1.) The major arteries of the area are Route 17, which joins Route 1 at Fredericksburg and extends through Yorktown to the

Newport News Ferry and south; Route 60, which with Route 168 brings traffic from Richmond, through Williamsburg, into Newport News and Hampton, and across the ferry at Willoughby Spit to Norfolk and Virginia Beach.

Traffic from the south uses Route 13 to Suffolk or Route 258 to Smithfield, and from either of these towns any of several roads to reach a particular part of the Peninsula. Route 31 leads south from the Jamestown Ferry, and Route 5 extends east through the Peninsula from an intersection with Route 31 just south of Williamsburg to Richmond. This road connects the area with Hopewell and Petersburg by way of the Hopewell Ferry and provides access to Brandon, Shirley and other old plantations along the James River which are favorite garden tour stops.

The focal point of the roads in the Festival area is Williamsburg, although it is possible for a motorist to by-pass the city by Route 168. Leading into the city from the east and west are Routes 60 and 168, and from the north and south, Route 31 and the Colonial Parkway. At present the Colonial Parkway goes from Yorktown to Williamsburg and Route 31 from Williamsburg to Jamestown; but by 1957 the Colonial Parkway will be extended from Williamsburg almost directly south to the James River where it will turn sharply west and proceed along a system of causeways to Jamestown Island.

Route 31 will lead along a portion of Route 618 to a new ferry slip west of the present one, which is to be abandoned. The old part of Route 31 extending southwest from the present intersection with Route 618 will terminate short of the Parkway. A new approach to Williamsburg will be furnished by Route 132 which will intersect with Route 168 and, in the city, the Parkway. The system of roads in the Festival area as it will be in 1957 is shown in Figure 2.

Exhibits and Special Events

The activities specifically planned for Yorktown will have their primary impact on roads under the jurisdiction of the National Park Service and were not within the scope of the study. However, the reconstructions and exhibits planned for Jamestown Island and Glasshouse Point—situated not far from Jamestown near the mouth of Powhatan Creek—will have a pronounced effect on traffic patterns

in the area, especially the use of the new section of the Colonial Parkway.

In this area, plans called for the reconstruction of the Third State House; a reproduction of James Fort; a reception center; a restaurant; buildings to house art displays; models of the three ships which brought the settlers from England; a restoration of the Glass Works; and domestic, craft, and agricultural exhibits. Nearer Williamsburg, adjacent to the campus of the College of William and Mary, will be located the Festival Exhibition Area and the Lake Matoaka Amphitheatre where a historic drama will be presented. In Williamsburg several new restorations will be made which will add to the already high level of attractiveness of the city.

Special events planned for this country are:

1. Cape Henry celebration (April 26, 1957), commemorating the landing and planting of the cross by the settlers. This is envisioned as primarily a religious observance with the Archbishop of Canterbury, the Lord Bishop of London, the Presiding Bishop of the United States, the Bishop of Southern Virginia, and others in attendance.

2. Old Point Comfort celebration (April 30, 1957), commemorating the landing at Old Point, the oldest fortified place in English-speaking America. This is envisioned as primarily a military observance.

3. Hampton Roads celebration (May 2, 1957), commemorating the landing at Newport News. It was suggested that this event should celebrate the founding of the port of Hampton Roads.

4. Jamestown Settlement celebration (May 13, 1957), commemorating the settlers' arrival at Jamestown. It was proposed that the President of the United States visit Jamestown on this day, and that the official opening of the museum, parkway, and restored Capitol, and the first performance of the Jamestown drama in Matoaka Amphitheatre should take place.

5. Royal Dominion celebration (June 16, 1957), commemorating the dissolution of the London Company in 1624, and the establishment of Virginia as a Royal Dominion. It was proposed that Queen Elizabeth II of England be invited to be present for this occasion.

6. General Assembly celebration (July 30, 1957), commemorat-

ing the convening of the first session on July 30, 1619, of the Virginia legislature—next to the British Parliament, the oldest legislative body in the English-speaking world. It was suggested that Sir Winston Churchill and Lady Astor be guests of honor as the Virginia General Assembly convenes in commemorative session at the Church at Jamestown.

7. Prelude to Independence Program (May 15–July 4, 1957). It was proposed that Colonial Williamsburg celebrate, with an enlarged activity program, this period from the adoption of the Virginia Resolves for Independence in Williamsburg on May 15, 1776, to the enactment of the Declaration of Independence of July 4, 1776.

8. Yorktown Day (October 19, 1957), commemorating the end of the colonial period with the winning of independence at Yorktown.

9. Treaty of Paris Day (November 30, 1957), commemorating the 175th anniversary of the completion of agreement in 1782 by the Commissioners at the Paris Peace Conference, whereby Great Britain recognized the independence of the thirteen original colonies. This was to be the final special event of the anniversary year.

Table I

AVERAGE DAILY TRAFFIC: ROUTES IN THE FESTIVAL AREA

Route	*1950*	*1951*	*1952*	*1953*	*1954*
31–N	1,175	1,100	1,185	1,400	1,700
31–S	1,750	1,950	2,200	2,550	2,430
60–N	1,800	1,700	1,575	1,420	1,800
60–E	2,800	2,800	3,560	4,230	4,340
60–Z	4,485	4,200	5,000	4,450	5,330
162	1,230	1,800	2,020	1,910	2,700
163	250	230	300	320	465
168	1,825	2,100	3,600	3,500	3,730
Total*	15,315	15,880	19,440	19,780	22,495
Percent increase over previous year		3.68	22.41	1.74	16.00

* Excludes the Colonial Parkway from Williamsburg to Yorktown.

Table I shows the average daily traffic on all important routes in the Festival area for the years 1950 through 1954. Daily traffic vol-

umes on all roads in the area have increased substantially except on Route 60 north between Route 60Z and the city limits of Williamsburg. Since the development of Route 168 this section of Route 60 has become more of a local service road than a principal artery.

Local conditions, particularly the development of new residential sections between Williamsburg and Newport News, have exerted some influence on traffic volumes; but the figures also reflect the rising number of visitors to Williamsburg as well as the general travel increase in the state as a whole.

Not shown in Table I is Route 31 from its intersection with Route 5 to Jamestown and over the ferry. In 1950, the average daily traffic on this road between Route 5 and Jamestown was 1,170 vehicles. By 1954 this figure had increased to 1,620. Average daily ferry traffic rose from 157 vehicles in 1950 to 250 in 1954. On the south side of the river, daily volumes increased from 380 to 620.

Also excluded, because of lack of data for the period in question, is the Colonial Parkway from Williamsburg to Yorktown. In 1954 this road carried an average of 1,350 vehicles per day.

Normal Growth in Total Traffic

The first step toward estimating the number of vehicles expected during the Festival was a projection of the normal trend. To simplify the procedure it was assumed that all traffic attracted to the area would pass through Williamsburg. This seems reasonable enough, since it appeared improbable that more than a negligible number of vehicles would enter the area by the Yorktown Bridge or Jamestown Ferry and leave the same way without coming far enough north or south to enter the city.

Projections of the 1953–54 average daily traffic on the routes entering Williamsburg (20,125 including the Colonial Parkway but excluding Route 168) yielded a figure for 1957 of 23,100. The composition of this traffic by class of vehicle and individual route is shown in Table II.

Separate estimates were prepared for each route expected to be in use in 1957. Several factors were given consideration in preparing these estimates: The relative status of each route in the highway network to be in use by 1957; the relative volumes of Virginia cars,

out-of-state cars, and other vehicles using the route; past usage trends; the service provided by each route; and patterns of travel into and within the area. Some conjecture was required in anticipat-

Table II

NORMAL AVERAGE DAILY TRAFFIC ENTERING AND LEAVING WILLIAMSBURG BY CLASS OF VEHICLE AND PRIMARY ROUTE

Route	*Virginia Cars*		*Foreign Cars*		*Other Vehicles*		*Total*	
	1953–54	*1957*	*1953–54*	*1957*	*1953–54*	*1957*	*1953–54*	*1957*
31–N	1,304	1,350	284	300	120	130	1,708	1,780
31–S	1,855	1,200	337	150	238	220	2,430	1,570
60–N	1,453	1,600	74	80	275	300	1,802	1,980
60–E	3,450	3,750	554	600	337	360	4,341	4,710
60–Z	4,325	4,550	379	425	626	700	5,330	5,675
132*	—	825	—	125	—	100	—	1,050
162	1,928	2,175	479	550	293	325	2,700	3,050
163	394	450	57	70	13	15	464	535
Col. Pway. E.	1,000	1,125	300	350	50	75	1,350	1,550
Col. Pway. W.†	—	900	—	250	—	50	—	1,200
Total	15,709	17,925	2,464	2,900	1,952	2,275	20,125	23,100

* Proposed connection between Route 168 and Colonial Parkway.
† New route to be constructed between Williamsburg and Jamestown.

ing the nature of certain features of the new routes, their termini, and related factors; but preliminary planning information was adequate for the immediate needs.

Addition of the estimates for each route gave an overall normal traffic increase from 1953–54 to 1957 of about 14.5 percent. This increase is consistent with the statewide traffic growth forecast in a 1954 needs study in which an annual growth factor averaging about 4.3 percent for the period 1954–65 was reported.

The largest numerical increase will be in Virginia vehicles, but present trends indicate that in proportion to the total, the number of foreign cars will increase more rapidly. Most of the out-of-state vehicles will appear on Routes 60Z, 60 east of Williamsburg, 31 at the southwest city limits, 132 and 162.

The construction of the Colonial Parkway from Williamsburg to Jamestown will divert traffic from Route 31 south to such an extent that a decline in the number of vehicles using 31 south can

be expected. Similarly, the connection between Route 168 and the Colonial Parkway, Route 132, is expected to attract traffic which ordinarily would have used Route 31 between Williamsburg and Route 168; therefore, the increase in traffic using Route 31 north will be slight.

Seasonal Traffic Patterns

The average daily traffic figure for an entire year is of relatively little value in planning for shorter periods since the type and amount of

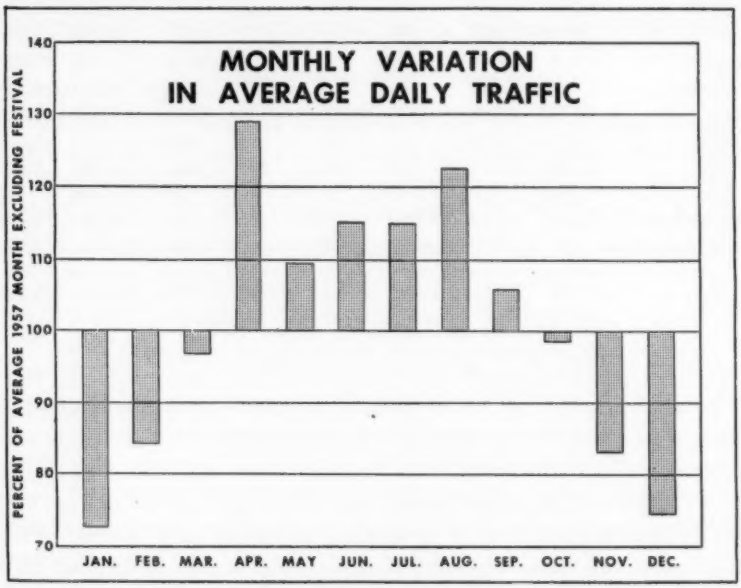


FIGURE 3.

travel show much variation throughout the year. Consequently, estimates of the month-to-month variation in travel in the Williamsburg area were prepared. Figure 3, the data for which came from traffic counts and attendance records of Colonial Williamsburg, shows the monthly variation in travel in the Williamsburg area.

This chart shows that January, February and March are below average. April is the high month of the year with travel about 30 percent above the average. The seasonal pattern then shows a de-

cline from April to May, but May is still some 10 percent above average. A slight increase is noted for June; July is about the same, and then a second peak occurs in August. September marks the beginning of a decline that continues until the end of the year.

Table III presents the estimates of average daily traffic expected by months during 1957 if only normal traffic growth were experienced.

To sum up, the first and last quarters of the year are below average while the middle half is above average. The yearly high is in April with a second peak in August.

Table III

ESTIMATED NORMAL AVERAGE DAILY TRAFFIC ENTERING AND LEAVING WILLIAMSBURG BY MONTHS 1957

Month	*ADT*
January	16,500
February	19,250
March	22,000
April	29,850
May	25,350
June	26,500
July	26,500
August	28,050
September	24,350
October	22,750
November	19,000
December	17,000
Average for year	23,100

In addition to the month-to-month variation a noticeable weekly pattern existed which is interdependent with the monthly variation. Figure 4 shows this pattern; Monday through Thursday are about 90 percent of average, Friday is about average, while Saturday and Sunday are well above average. Saturday traffic is approximately 25 percent above average travel and Sunday traffic is nearly 20 percent over average.

Much of the Saturday traffic peak is the result of an increase of domestic vehicles rather than foreign. Generally it appears that foreign vehicle travel in the area is fairly even throughout the week. It should be noted that this day-to-day variation is combined with

the monthly variation. Increased travel due to holidays and holiday weekends was about as follows:

First two or three days of January	up 10 percent
February 21–23	up 20 percent
Easter Weekend	up 15 percent
May 29–31	up 15 percent
July 4th	up 10 percent
Labor Day Weekend	up 15 percent
Thanksgiving (Wednesday–Sunday)	up 10 percent
December 22–26	up 20 percent
December 30–31	up 10 percent

The Effect of the Festival

Before stating an estimate of expected increases in travel due to the Jamestown Festival attractions, it must be emphasized that the promotional activities (both the quantitative and qualitative aspects) can affect tremendously the volume and type of traffic. But even

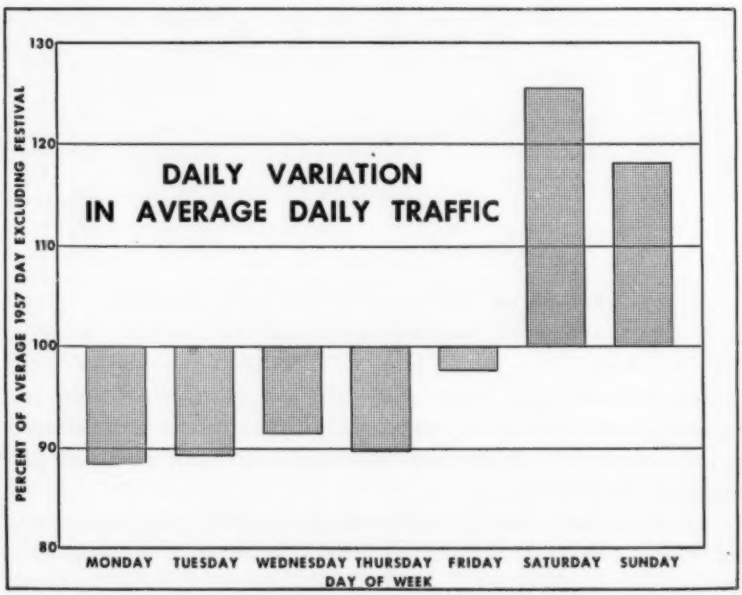


FIGURE 4.

without special advertising, it seemed reasonable to assume that the added features and sights open throughout the Festival period would generate a substantial increase in travel over and above the normal increase expected by 1957.

Estimates of traffic volumes expected during the 1957 celebration included the combined effect of two separate and distinct increases. First, the normal increase outlined above would occur even if the Festival were not planned; in addition, the Festival itself will generate an increase in traffic above the normal.

The former increase will apply for the entire 1957 calendar year; the latter will be active only during the Festival period. Table IV summarizes the estimates of average daily traffic by class of vehicle expected from April 1 to November 15, 1957. This period includes the months of heaviest travel; the balance of the year, when travel should be light in comparison, has been excluded.

Table IV

ESTIMATES OF AVERAGE DAILY TRAFFIC ENTERING AND LEAVING WILLIAMSBURG BY CLASS OF VEHICLE

Class of Vehicle	*1953–54*	*Estimated Normal 1957 Traffic**	*Percent Increase Over 1953–54*	*Estimated Festival Traffic***	*Percent Increase Above Normal*	*Percent Increase Over 1953–54*
Virginia cars	15,709	17,925	14	20,600	15	31
Foreign cars	2,464	2,900	17.5	3,950	36	60
Other Vehicles	1,952	2,275	16.5	2,450	8	25
Total	20,125	23,100	14.5	27,000	17	34

* For calendar year.
** For Festival months only.

From this table it can be seen that the average daily traffic expected during the Festival is estimated to be about 27,000 vehicles. Relative to 1953–54 traffic, out-of-state cars show the greatest percentage increase and Virginia cars show the largest increase in numbers.

Separate estimates were prepared for each class of vehicle. For Virginia cars, special traffic surveys and tourist studies were the primary sources of information. Supplementing these for the out-of-state estimate were data on recent visitors to major attractions in

the state. "Other vehicles" were estimated from data gathered in traffic studies for the general area. The three separate estimates when combined give a Festival traffic estimate about 17 percent above the normal traffic forecast for 1957 and 34 percent above 1953–54 traffic.

The number of vehicles actually bringing visitors to the Festival is estimated to average about 3,000 per day. This figure includes newly induced Festival traffic plus the vehicles which would ordinarily bring people to non-Festival attractions in Williamsburg and vicinity. The basis for this estimate is the traffic-generating effect of major attractions recently staged in Virginia and consideration of the attractiveness of the Williamsburg area to visitors and tourists.

Festival Traffic by Routes

The estimated average daily traffic during the Festival is distributed by primary routes entering and leaving Williamsburg as shown in Table V.

Table V

Estimated Average Daily Traffic Entering and Leaving Williamsburg by Primary Route and Class of Vehicle During Festival

Route	*Virginia Cars*	*Foreign Cars*	*Other Vehicles*	*Total*
31–N	1,600	400	150	2,150
31–S	1,000	150	200	1,350
60–N	1,600	100	300	2,000
60–E	3,900	650	400	4,950
60–Z	4,700	450	700	5,850
132	1,000	250	75	1,325
162	2,200	600	350	3,150
163	500	100	50	650
Col. Pway. E.	2,200	700	125	3,025
Col. Pway. W.	1,900	550	100	2,550
Total	20,600	3,950	2,450	27,000

This traffic distribution by routes is based on extensions of past traffic plus an assignment of traffic to the new roads, Route 132 and the Colonial Parkway to Jamestown. Obviously, all routes will not show the same proportionate increase, and in making these estimates, certain factors were recognized and their probable effects evaluated.

Among these factors are: 1. Completion of the Colonial National Monument Parkway from Williamsburg to Jamestown will certainly attract traffic which now uses Route 31 southwest of Williamsburg. 2. Final location of the reception center, parking lots, and other new facilities may alter distribution of traffic using the various routes. 3. There are not enough data available to make accurate estimates of the effect of the new entrance to Williamsburg (Route

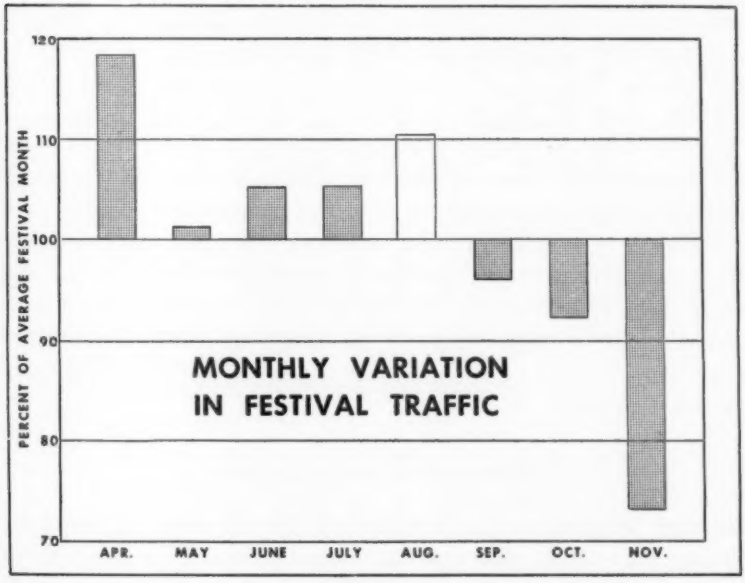


FIGURE 5.

132). However, the proposed location is such that much of the traffic using Route 132 should be diverted from Route 31 north of Williamsburg.

Table V presents estimates based on the full period during which most or all of the Festival attractions will be available. In preparing this tabulation no consideration was given to special events of a nonrecurring nature; and no allowance was made for the month-to-month variation which is expected. However, Table VI and Figure 5 present the estimates of average daily traffic by months of the Festival period.

Table VI

AVERAGE DAILY TRAFFIC DURING FESTIVAL BY MONTHS

Month	*Estimated ADT*
April	31,250
May	26,750
June	27,750
July	27,750
August	29,250
September	25,500
October	24,500
November	19,500

To reiterate, these estimates exclude the effects of any major attractions or events which are not to be continued throughout the Festival; they represent basic amounts to which the travel induced by special activities must be added. The maximum volumes of traffic which may be expected should be estimated for each event but in any case, the limiting factors before congestion results will be the capacity of the highways leading to and from the area and the availability of parking and other facilities in the area.

Volumes and Route Capacity

In 1957, Williamsburg will be served directly from the north by Routes 31, 60, 60Z, and 132; east by the Colonial Parkway; south by Routes 60, 162 and 132; west by Route 31 and the Colonial Parkway. The capacity of these roads will remain a constant factor regardless of the variation in traffic. For the entire year 1957, the capacity of all roads in the area will be adequate except that of Route 60 east of the city and in this case the traffic can be diverted to parallel Route 168 which has ample room for it.

But it must be remembered that within the year there is a normal monthly variation; that in 1957 the Festival period will show an abnormally large increase over the average for the year: that within the months there may be a weekly variation; and, finally, within the weeks there is a daily variation.

Table VII shows the relationship of traffic to capacity during

Table VII

Average Daily Traffic and Route Capacity: Saturdays in Festival Period

Route	*Capacity*	*ADT*		*Saturdays in April*		*May*		*June*		*July*		*August*		*September*		*October*		*November*	
31–N	14,000	2,150	6.5*	3,000	4.7	2,550	5.5	2,650	5.3	2,650	5.3	2,800	5.0	2,450	5.7	2,350	5.9	1,900	7.3
31–S	3,500	1,350	2.6	1,875	1.8	1,600	2.2	1,675	2.1	1,675	2.1	1,750	2.0	1,550	2.3	1,475	2.4	1,200	2.9
60–N	3,500	2,000	1.7	2,800	1.2	2,400	1.5	2,475	1.4	2,475	1.4	2,600	1.3	2,275	1.5	2,200	1.6	1,750	2.0
60–E	3,500	4,950	0.7	6,900	0.5	5,900	0.6	6,100	0.6	6,100	0.6	6,400	0.5	5,600	0.6	5,400	0.6	4,300	0.8
60–Z	8,000	5,850	1.4	8,100	1.0	7,000	1.1	7,200	1.1	7,200	1.1	7,600	1.0	6,600	1.2	6,400	1.3	5,100	1.6
132	3,500	1,325	2.6	1,850	1.9	1,600	2.2	1,650	2.1	1,650	2.1	1,725	2.0	1,500	2.3	1,450	2.4	1,150	3.0
162	4,000	3,150	1.3	4,350	0.9	3,750	1.1	3,900	1.0	3,900	1.0	4,100	1.0	3,600	1.1	3,450	1.2	2,750	1.5
163	2,700	650	4.1	900	3.0	775	3.5	800	3.4	800	3.4	850	3.2	750	3.6	700	3.9	575	4.7
Col. Pway. E.	9,000	3,025	3.0	4,200	2.1	3,600	2.5	3,750	2.4	3,750	2.4	3,950	2.3	3,450	2.6	3,300	2.7	2,650	3.4
Col. Pway. W.	3,500	2,550	1.4	3,550	1.0	3,050	1.1	3,150	1.1	3,150	1.1	3,350	1.0	2,900	1.2	2,800	1.2	2,250	1.6

* Ratio of $\frac{\text{Capacity}}{\text{ADT}}$

the Festival period for the most unfavorable day of the week—Saturday—when about 25 percent more cars than the average for the week can be expected. It can be seen that on Saturday Route 60E will be deficient in capacity during the entire period and steps should be taken to divert some of the cars on this road to Route 168.

Route 162 will be crowded beyond its capacity on Saturdays in April and August, and some of its traffic should be diverted to Route 31 or the Colonial Parkway. Route 60Z and the Colonial Parkway west will be crowded on Saturdays in April; here diversion is not practical, but fortunately the traffic using these roads should not be greatly in excess of their capacity and conditions should be tolerable.

On Sundays volumes will probably be slightly lower than on Saturdays but the same diversions should be made. Route 168 has been omitted from the table because its capacity is more than double its anticipated Festival ADT.

From Monday through Thursday, as Table VIII indicates, all of the roads will be adequate with the exception of Route 60E, where traffic can be diverted to Route 168. On the holidays that occur during the Festival period, as shown in Table IX, several of the roads will again be crowded beyond capacity, and the same diversionary measure suggested for Saturdays and Sundays should be placed in effect.

It was difficult to make an estimate of peak traffic hours in the average Festival day, but they probably will conform fairly closely to the usual pattern of increasing volumes to a mid-morning peak; a decline until the lunch hour when there is another, but smaller peak; then a mid-afternoon peak, and a decline for the balance of the day. The important point is that there will be especially heavy traffic at certain times during the Festival. State police forces should be deployed in the most effective way to keep traffic moving.

If congestion is to be avoided, Festival authorities should not schedule for these days special events that will induce even more traffic. If the purpose of the Festival requires that certain celebrations be held on holidays, such as the Fourth of July, advertising of the event probably should be minimized. However, in general it appears that the network of roads in the area will be adequate to accommodate the traffic the Festival will generate provided the necessary diversions are made.

Table VIII

Average Daily Traffic and Route Capacity: Mondays Through Thursdays in Festival Period

Route	*Capacity*	*ADT*		*Mondays through Thursdays in April*		*May*		*June*		*July*		*August*		*September*		*October*		*November*	
31–N	14,000	2,150	6.5*	2,275	6.1	1,950	7.2	2,025	6.9	2,025	6.9	2,125	6.6	1,850	7.6	1,775	7.9	1,425	9.8
31–S	3,500	1,350	2.6	1,425	2.5	1,225	2.9	1,275	2.7	1,275	2.7	1,350	2.6	1,175	3.0	1,125	3.1	900	3.9
60–N	3,500	2,000	1.7	2,225	1.6	1,900	1.8	1,975	1.8	1,975	1.8	2,000	1.7	1,825	1.9	1,750	2.0	1,400	2.5
60–E	3,500	4,950	0.7	5,200	0.7	4,450	0.8	4,650	0.8	4,650	0.8	4,900	0.7	4,250	0.8	4,100	0.9	3,250	1.1
60–Z	8,000	5,850	1.4	6,200	1.3	5,300	1.5	5,500	1.5	5,500	1.5	5,750	1.4	5,050	1.6	4,850	1.7	3,850	2.1
132	3,500	1,325	2.6	1,400	2.5	1,200	2.9	1,250	2.8	1,250	2.8	1,300	2.7	1,150	3.0	1,100	3.2	900	3.9
162	4,000	3,150	1.3	3,325	1.2	2,850	1.4	2,950	1.4	2,950	1.4	3,100	1.3	2,700	1.5	2,600	1.5	2,075	1.9
163	2,700	650	4.1	700	3.9	600	4.5	625	4.3	625	4.3	650	4.1	575	4.7	550	4.9	450	6.0
Col. Pway. E.	9,000	3,025	3.0	3,200	2.7	2,725	3.3	2,850	3.2	2,850	3.2	3,000	3.0	2,600	3.5	2,500	3.6	2,000	4.5
Col. Pway. W.	3,500	2,550	1.4	2,700	1.3	2,300	1.5	2,400	1.5	2,400	1.5	2,525	1.4	2,200	1.6	2,100	1.7	1,675	2.1

* Ratio of $\frac{\text{Capacity}}{\text{ADT}}$

Table IX

AVERAGE DAILY TRAFFIC AND ROUTE CAPACITY: HOLIDAYS IN FESTIVAL PERIOD

Route	*Capacity*	*ADT*		*April 20–21 Easter Weekend*		*May 29–31 Memorial Day*		*July 4–6 Independence Day*		*Aug. 31, Sept. 1–2 Labor Day Weekend*	
31–N	14,000	2,150	6.5*	3,450	4.1	2,950	4.7	2,925	4.8	3,225	4.3
31–S	3,500	1,350	2.6	2,150	1.6	1,850	1.9	1,850	1.9	2,025	1.7
60–N	3,500	2,000	1.7	3,225	1.1	2,750	1.3	2,725	1.3	3,000	1.2
60–E	3,500	4,950	0.7	7,950	0.4	6,750	0.5	6,700	0.5	7,350	0.5
60–Z	8,000	5,850	1.4	9,300	0.9	8,050	1.0	7,925	1.0	8,750	0.9
132	3,500	1,325	2.6	2,125	1.7	1,825	1.9	1,800	1.9	2,000	1.7
162	4,000	3,150	1.3	5,000	0.8	4,300	0.9	4,300	0.9	4,700	0.8
163	2,700	650	4.1	1,025	2.6	900	3.0	900	3.0	1,000	2.7
Col. Pway. E.	9,000	3,025	3.0	4,850	1.9	4,150	2.2	4,125	2.2	4,550	2.0
Col. Pway. W.	3,500	2,550	1.4	4,100	0.9	3,500	1.0	3,475	1.0	3,850	0.9

* Ratio of $\frac{\text{Capacity}}{\text{ADT}}$

The Jamestown Ferry

From 1950 to 1954 the daily average number of vehicles using the ferry between Scotland Neck and Jamestown increased from 157 to 250, a rise of 59 percent. The ferry traffic represented only 41 percent of Route 31 traffic on the south side of the James River in 1950 and 1954. In spite of the effect of the Festival, it is unlikely that volumes on Route 31 south of the James River will show as great a proportionate increase in 1957 as roads nearer Williamsburg because of its distance from the Festival and the river barrier.

The normal increase for this route should be about 12 percent and Festival traffic will probably add another 3 percent, making an estimated ADT of 715. If the relationship between Route 31 traffic and ferry traffic that prevailed in the past remains good in the future, a daily volume of 290 can be expected. This figure represents an addition of only forty vehicles daily to the 1954 volume, and at this rate even weekend and holiday traffic should not put an unreasonable burden on ferry facilities.

Value of the Estimates

Estimates of traffic provided a basis for further computations. Combined with attendance data from the records of Colonial Williamsburg, the traffic figures enabled an estimate of attendance to be made which provided Festival authorities with a yardstick to measure available accommodations and restaurant facilities. Some insight into future parking conditions was also gained so that recommendations could be made as to the number and approximate location of new spaces needed. Decisions regarding traffic control in Williamsburg were also based on the traffic estimate and the assignment of 1957 vehicles to routes.

Indeed, a great deal of the planning for the Festival has its roots in the traffic figures; their validity can be the difference between order and chaos.

Using Creeper Lanes for Trucks On West Virginia Turnpike

ELMER K. TIMBY

Mr. Timby is a partner in the firm of Howard, Needles, Tammen and Bergendorff, consulting engineers. Direction of and responsibility for projects handled by the partnership are assigned to individual partners and Mr. Timby's assignments have included the West Virginia Turnpike, Delaware Memorial Bridge, Hampton Roads Bridge and Tunnel Project, North Carolina Turnpike, and the Pennsylvania and Newark Bay–Hudson County extensions of the New Jersey Turnpike. He was a member of the Civil Engineering faculty of Princeton University from 1928 to 1949 and during those years acted also as consultant on various projects such as the Golden Gate Bridge, San Francisco–Oakland Bridge, Bronx-Whitestone Bridge, and the Philadelphia-Camden Suspension Bridge. In 1936–37, Mr. Timby developed a special testing machine and made a large model of a floating dry dock to handle the largest ships of the United States Navy. He is a member of the American Society of Civil Engineers, American Institute of Consulting Engineers, Highway Research Board and other professional organizations. He is a licensed Civil and Professional engineer in New Jersey, Virginia, West Virginia, North Carolina and South Carolina.

EARLY in the planning of the West Virginia Turnpike in 1950 it became evident that traffic would not need a fully dualized facility. Accordingly, it was decided that the normal roadway would consist of two twelve-foot traffic lanes flanked by heavy duty, paved shoulders, nine feet wide.

On long grades of between three and five percent (the maximum) through particularly mountainous terrain, a third twelve-foot lane flanked by a paved shoulder two feet wide would be used on the up-grade to accommodate truck traffic. These "creeper lanes" as they have come to be known are as distinctive a feature of the West Virginia Turnpike as the rugged country it traverses.

It may seem strange that creeper or truck climbing lanes should be associated with a turnpike at all. The public thinks of a turnpike as a superhighway, a gilt-edged road embodying the latest features

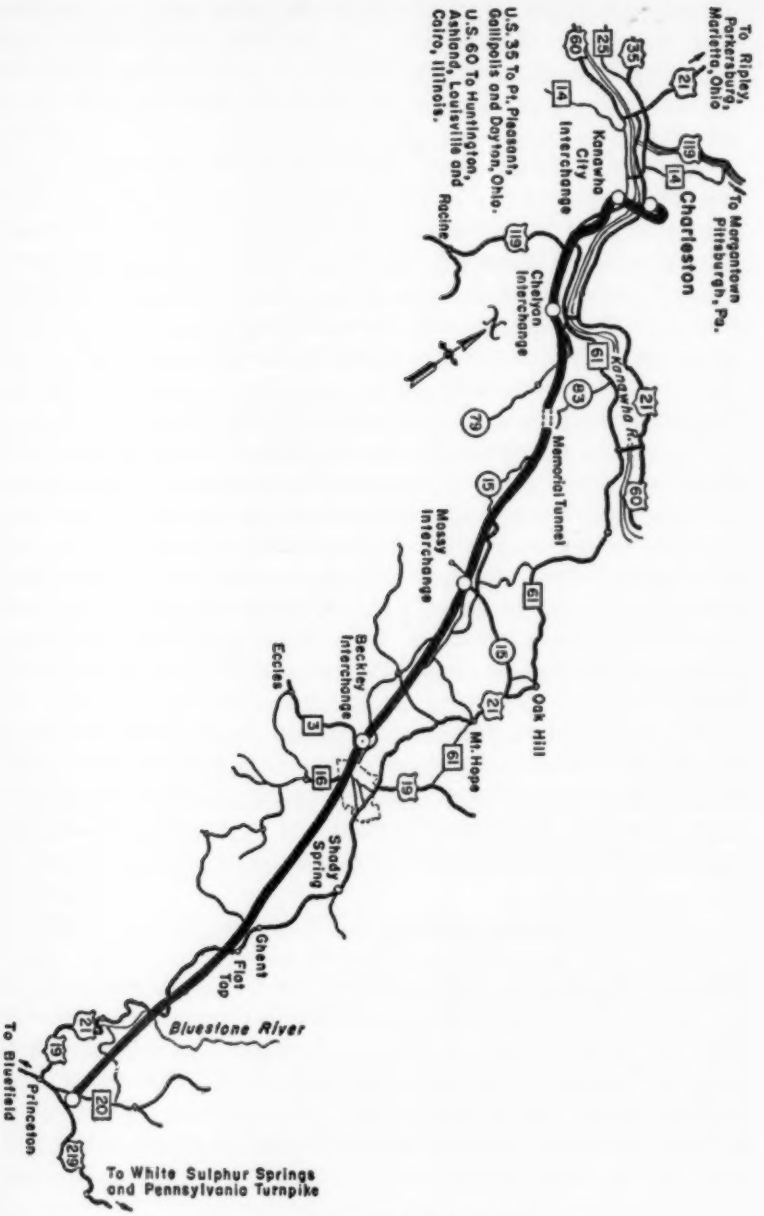


FIGURE 1. The West Virginia Turnpike.

of modern highway construction—all that the prefix *super* implies. That conception of a turnpike suggests little need to effect economies in design or construction. It may be well, therefore, to discuss the nature of turnpikes in general and of the West Virginia Turnpike in particular.

In the years following the end of World War II there arose in this country an overwhelming need for improved highways. This is an established fact; the causes need not concern us here. Methods then existing for financing new construction from public funds were completely inadequate to meet the need. Beginning with the original Maine Turnpike, and later with the New Jersey and other turnpikes, private funds were invested in revenue bonds which were secured by the pledge of the turnpike revenues. During the life of the bonds, these roads function as toll highways.

For several reasons, toll roads are built to superior standards. First is the desire to afford the traveling public the maximum in convenience, safety and speed consistent with justifiable construction cost. Second, since toll roads do compete with existing, parallel free highways, they must appear attractive enough in convenience, economy and safety to induce potential traffic to use them for a fee in preference to the free route. Third, their superiority to competing free routes must be assured throughout the life of the revenue bonds.

For these reasons durability to insure low maintenance costs, superior horizontal and vertical alignments, limited access, adequate right-of-way and provisions for future expansion, if that becomes necessary, all assume the stature of imperatives rather than desirables in the design of a toll highway.

Terrain Affected Turnpike Design

Although in practice most turnpikes are designed and built as multi-lane, divided, limited access highways, there is no reason why they must be so constructed. The fundamental idea is to provide a traffic facility in keeping with the need. Most toll highways are located in regions of naturally high traffic densities. The existing highways in such regions have usually reached capacity, and frequently they are worn out or substandard as well.

In such places, a turnpike usually serves to relieve congestion on existing heavily traveled free highways, while at the same time providing capacity for traffic yet to come. In this way, public funds, to the extent that they exist, are spared from being used to expand and improve an existing route at outrageous cost and are released for more profitable construction elsewhere.

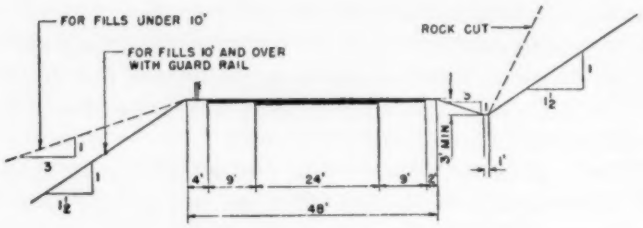
There are, however, other conditions under which toll highways become desirable solutions to the problem of how to provide adequate highways. The West Virginia Turnpike affords a good example of one of these other conditions.

West Virginia occupies a unique position among the states east of the Mississippi River. Although in a central position, industrially as well as geographically, among the eastern states and having natural resources and potential wealth of great importance, the state is plagued by terrain so rugged and forbidding that transportation within and through it has been most difficult. Even with large amounts of time and money expended to improve transportation, rail and highway facilities have remained generally inadequate. There are no important north-south rail movements in the state; before the Turnpike, there were no approximately modern or adequate north-south highways.

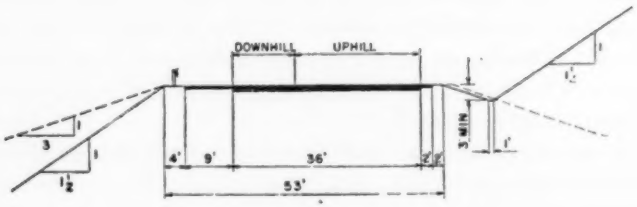
It is the latter situation which made the conditions of planning the West Virginia Turnpike differ from others. It supplies a highway where before there was for all practical purposes none. Except for minor local traffic there are no *competing* free roads. Therefore, although the quality of the road had to be high and has to remain so throughout the years, it did not have to supply from the outset vehicular capacity equivalent to a New Jersey or Pennsylvania Turnpike.

What was indicated was a highway that would serve the demands of the traffic willing to use it now in preference to both the much longer route *around* West Virginia and the tortuous routes within the state. That there was such potential traffic was established by specific origin and destination surveys. Moreover, engineering analyses of traffic and construction costs clearly showed that construction of a multi-lane divided highway could not be justified initially by the anticipated revenues, though ultimately such a highway may be both needed and economically possible.

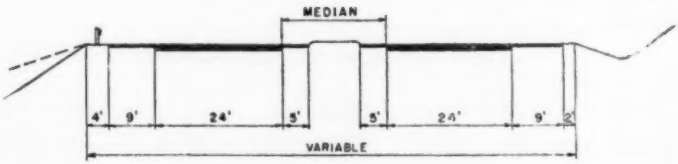
Accordingly, it was early decided to construct a superior two-lane highway, properly designed, with flat grades, long radius curves, long sight distances, and wide, paved shoulders on either side. It



TYPICAL TWO LANE SECTION



TYPICAL THREE LANE SECTION
FOR STEEP GRADES



TYPICAL FUTURE DUAL SECTION

FIGURE 2.

was of course fundamental that this arterial highway should have all grade crossings, left turns, and traffic signals eliminated so that it would be truly an expressway. In accordance with modern practice, no thought was given to the construction of a three-lane highway.

The condensed geometric design standards reproduced as Table I give the pertinent details. See also the typical cross sections. Throughout the design of the Turnpike, the anticipated future dualization was constantly kept in mind. Accordingly thirty miles or 35 percent of the total 86.7-mile length is on wide embankment or cut. Of this length, 5.7 miles were dualized initially through interchanges and service areas to minimize interference with traffic when the entire highway is later dualized. The remaining 24.3 miles of wide embankment contains the sections of uphill truck or creeper lanes.

Climbing Lanes for Trucks Studied

There is reason enough for construction of climbing lanes for trucks on long grades which decrease speed. And, at the time the question was under consideration, there was little available in specific data on truck lanes. The Arizona Department of Highways and the Bureau of Public Roads had co-operated in a study of the climbing ability of trucks on various grades, and the results of this study were available to the public.

Washington State and Colorado were known to have employed climbing lanes, but the precise effects on the capacity of two-lane, limited access highways were mostly a matter of conjecture. Since that time numerous highway departments have employed climbing lanes on two-lane rural highways, and the results of several additional studies have been published and incorporated into the policies of the American Association of State Highway Officials.[1]

It was the study of uphill truck speeds on mountain grades that supplied the basic data on which were founded the geometric design

[1] See for example, "A Policy on Geometric Design of Rural Highways" published by AASHO, 1955; "Vehicle Climbing Lanes," Highway Research Board Bulletin 104, 1955; "Survey of Downhill Speeds of Trucks on Mountain Grades," Proceedings, Highway Research Board, January, 1951; and "Survey of Uphill Speeds of Trucks on Mountain Grades," Proceedings, Highway Research Board, 1949.

standards for creeper lanes on the West Virginia Turnpike. Many of the conclusions of later studies are not particularly useful in thinking about turnpikes. For example, economic considerations governing the use of climbing lanes on ordinary two-lane rural highways are not directly applicable to limited access highways. A highway planner in determining whether or not to construct or

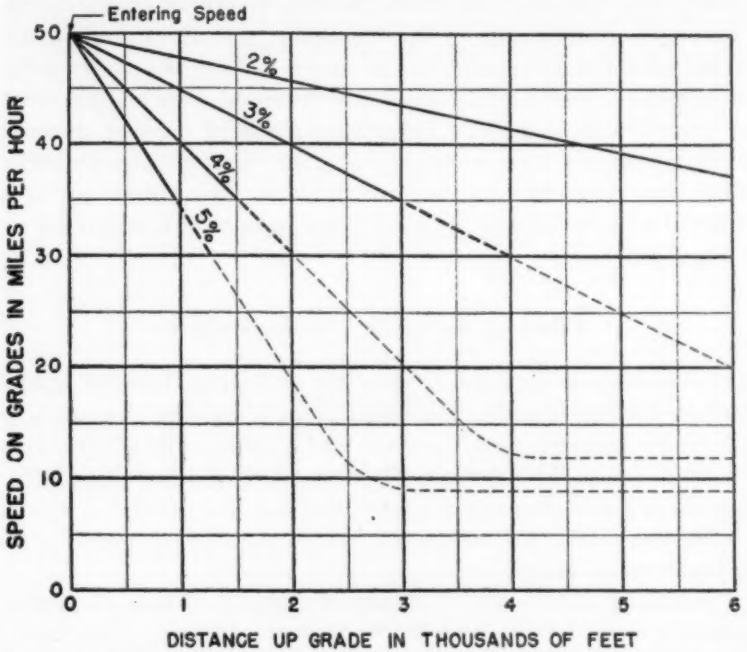


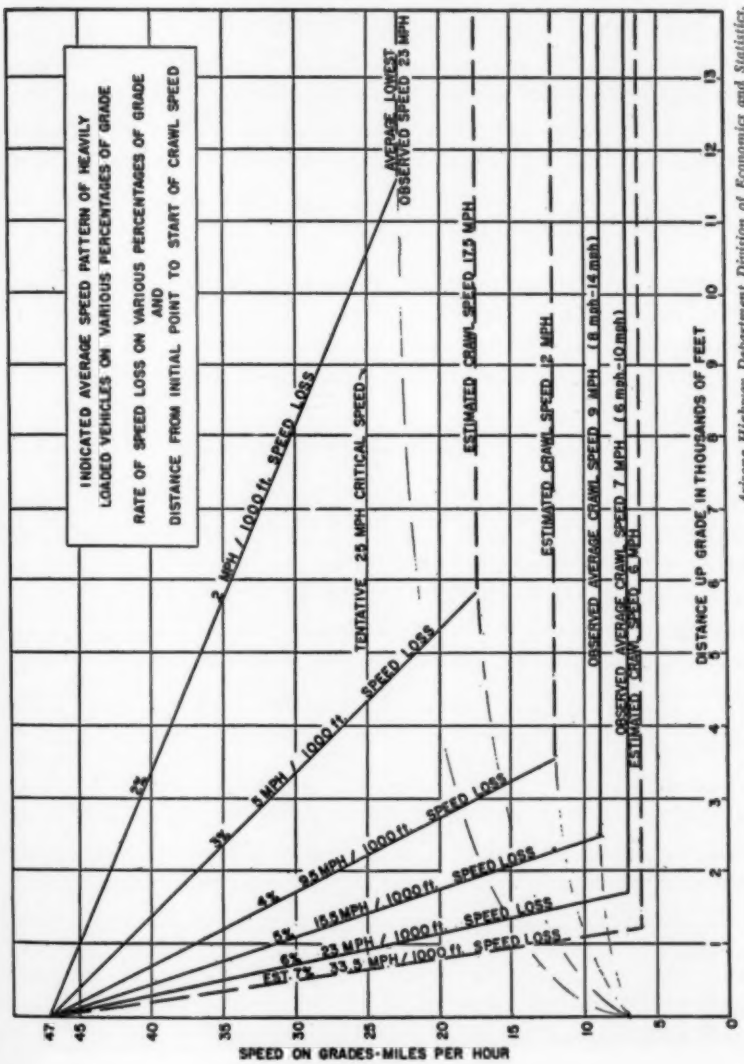
FIGURE 3. Uphill truck speeds. Rate of speed loss on various percentages of grade.

NOTE: Entering speed shall be assumed at beginning of tangent grade. When hill is composed of a series of different grades, the speed at the point of vertical intersection between the first grade and the second grade shall be assumed as the entering speed for the second grade, etc.

reconstruct a two-lane highway with passing bays (or creeper lanes) more often than not must justify the construction on the basis of cost-benefit ratios, difficult of precise evaluation.

Always, of course, planners must consider the question of safety. Frequently the planner will be forced to permit some degree of "tolerable" congestion on public highways, simply because there is no way to justify an expenditure of funds to eliminate it. But con-

gestion which is tolerable on a public highway is very definitely intolerable on a toll highway. Even though a toll highway could theoretically tolerate some congestion and still provide a more economical route than competing free routes, the effect of congestion


INDICATED AVERAGE SPEED PATTERN OF HEAVILY LOADED VEHICLES ON VARIOUS PERCENTAGES OF GRADE
RATE OF SPEED LOSS ON VARIOUS PERCENTAGES OF GRADE AND DISTANCE FROM INITIAL POINT TO START OF CRAWL SPEED
AVERAGE LOWEST OBSERVED SPEED 23 MPH
2 MPH / 1000 ft. SPEED LOSS
TENTATIVE 25 MPH CRITICAL SPEED
5 MPH / 1000 ft. SPEED LOSS
ESTIMATED CRAWL SPEED 17.5 MPH
ESTIMATED CRAWL SPEED 12 MPH
OBSERVED AVERAGE CRAWL SPEED 9 MPH (8 mph-14 mph)
OBSERVED AVERAGE CRAWL SPEED 7 MPH (6 mph-10 mph)
ESTIMATED CRAWL SPEED 6 MPH
8.5 MPH / 1000 ft. SPEED LOSS
10.5 MPH / 1000 ft. SPEED LOSS
23 MPH / 1000 ft. SPEED LOSS
EST. 7% 33.5 MPH / 1000 ft. SPEED LOSS
2%
3%
4%
5%
6%
DISTANCE UP GRADE IN THOUSANDS OF FEET
SPEED ON GRADES-MILES PER HOUR

Arizona Highway Department Division of Economics and Statistics.

FIGURE 4. Uphill Truck Speeds 1951. Plotted From 1948–49 Field Data.

even in relatively small amounts is to invite undue criticism. Free flow is a prime desideratum on a turnpike.

Consideration of the geometric design standards devoted to creeper lanes (Table I) and the Uphill Truck Speeds graph (Figure 3) demonstrates that the decision as to when and where to employ creeper lanes on the Turnpike was based on the momentum principle. Comparison with the charts worked out by the Arizona Highway Department in 1951 shows some significant differences (Figure 4). Where the Arizona charts show a tentative 25 MPH critical speed, the Turnpike standards adopted a 30 MPH critical speed where passing sight distance for 50 MPH was provided, and a 35 MPH critical speed where it was not.

Critical speed is understood to be the speed below which traffic should not be required to move because of obstructions; or in other words, the point at which a creeper lane should begin. The 30 MPH critical speed accords with the AASHO recommendation of minimum tolerable truck speed of half the design speed, 60 MPH.

Results Favorable from Creeper Lanes

Another difference is the range of grades displayed. The Turnpike's maximum grade is 5 percent, whereas the Arizona tests included grades up to 7 percent. The assumed entering speeds, too, differ. In the Arizona study, observations established an approach speed from a level grade of 47 MPH. On the Turnpike it was felt that acceleration on the frequent downslopes before entering the next up-grade would justify extrapolating the Arizona data to a 50 MPH average entering speed.

The point at which the creeper lane terminates seems adequate by any of the standards in use today. The minimum distance beyond the crest is 1,000 feet, provided that passing sight distance for 50 MPH is available. If it is not, the lane is continued to a point where sight distance is adequate, to a limit of 2,000 feet beyond the crest.

It is obvious that the capacity of the Turnpike, having as it does 35 percent of its total length widened to include climbing lanes, is far in excess of that which might be predicted for a major two-lane highway. It has carried with ease on peak days more than 16,600 vehicles without congestion.

FIGURE 5. Typical Creeper Lane on the West Virginia Turnpike.

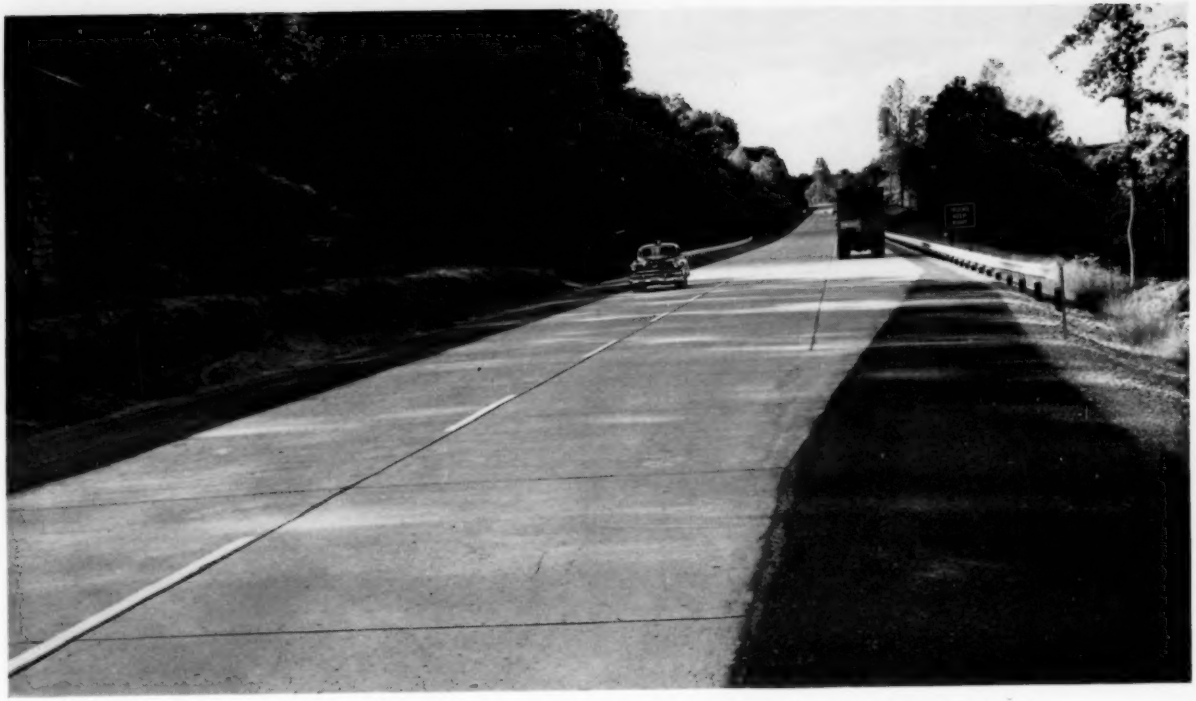


FIGURE 6. Start of Typical Creeper Lane. Signs recently changed to "Keep Right Except to Pass."

Originally the approaches to the creeper lanes were signed "Trucks Keep Right." Later this was changed to "Keep Right Except To Pass" to allow lighter, faster trucks to execute passing maneuvers. The approaches to the downhill lane are similarly signed. There is no special pavement marking. The pavement on the creeper lanes is of the same Portland cement concrete as the main roadway. Only the shoulders of the Turnpike are of asphalt concrete.

Experience with the creeper lanes on the Turnpike has been most favorable. Field observations show that trucks approach the beginning of the lanes at 30 MPH or more with very few exceptions. Passenger cars encounter only momentary slowing as the truck moves into the lane.

Once in the lane, trucks tend to space themselves 100 to 200 feet apart, and move from 10 to 20 MPH. Usually no more than three or four trucks are in a lane at any one time. Generally, trucks leave the lane to return to the pavement at not less than 30 MPH and usually the speed at this point is nearer 40 MPH. Trucks are observed to enter and leave creeper lanes by using the tapered sections.

Table I

WEST VIRGINIA TURNPIKE COMMISSION
CONDENSED GEOMETRIC DESIGN STANDARDS

DESIGN SPEEDS

A. Main Roadways.

60 m.p.h. (except: 40 m.p.h. through tunnel; and in such reduced speed zones as may be authorized by the general consultants).

HORIZONTAL ALIGNMENT

A. Main Roadways.

1. Relation of curvature to design speed.

	Degree of Curvature	
Design Speed Miles per Hour	*Desirable Maximum*	*Absolute Maximum*
60	3°—30 feet	5°—30 feet
*55		6°—45 feet
*50		8°—15 feet
*45		10°—00 feet

* To be used only where specifically authorized. All zones in which used are to be posted for the resulting speeds.

GRADES, ROADWAY WIDTH AND SHOULDER WIDTH

A. Main Roadways.

1. Length of profile tangent.
   Desirable minimum—800 feet.
   Absolute minimum—300 feet.

2. Maximum grade—5 percent.

3. Minimum grade.
   0.0 percent, except 0.30 percent to provide longitudinal drainage along the shoulder on those portions of the Turnpike where expansion into a 4-lane divided roadway adjacent to the initial 2-lane roadway is considered feasible.

4. Pavement width.
   a. 24 feet (except where creeper lane, or lanes, are required).
   b. 36 feet (creeper lane required for one direction of traffic).
   c. 48 feet (creeper lane required for both directions of traffic).
   When degree of curvature exceeds the desirable maximum degree of curvature for the designated design speed, width of pavement shall be increased by one foot on each edge and width of paved shoulders shall be reduced by the same amount. Super-elevation data to be modified accordingly.

5. Creeper lanes.
   Full-width creeper lanes shall be started where truck speed, as determined from Figure 3, decreases to 30 miles per hour and passing sight distance for 50 mile per hour speed is provided; or becomes 35 miles per hour if such passing sight distance is not provided at the 30 mile speed.

   Creeper lanes are not to be provided if the resulting uphill length of full-width lane becomes less than 300 feet and passing sight distance for 50 mile per hour speed is provided at the crest.

   Full-width creeper lanes shall be continued past the crest for not less than 1,000 feet and for not more than 2,000 feet, and shall be terminated at such intermediate point as may provide a passing sight distance for 50 mile per hour speed.

   Unless otherwise authorized the above criteria shall also be used to determine the points of starting and terminating creeper lanes in any zones where design speed less than 60 miles per hour may be specifically authorized.

   A tapered section 200 feet long shall be provided before the beginning of the full-width length and a tapered section 300 feet long shall be provided beyond the end of the full-width length of all such lanes.

6. Shoulders.

Paved shoulders shall be 9 feet wide except paved shoulders adjacent to creeper lanes which shall be 2 feet wide.

SIGHT DISTANCES AND VERTICAL CURVES

Vertical curves are to be used at any change of grade of 0.30 percent or more.

A. Main Roadways.

1. Passing sight distances are most desirable and vertical curves sufficient to provide them should be used at crests. Non-passing sight distances shall be maintained as the absolute minimum.
2. Minimum length of vertical curves in sags and at crests shall be 600 feet except as follows:
   a. For algebraic differences in grades of from 1.01 percent to 1.50 percent, minimum length of vertical curves shall be 500 feet.
   b. For algebraic differences in grades of from 0.30 percent to 1.00 percent, minimum length of vertical curves shall be 400 feet.
3. Unless greater interval is specifically authorized, passing sight distances shall be provided so that the distance between the end and beginning of adjacent safe passing sections will not exceed one mile.

B. Passing and Non-Passing Sight Distances (Main Roadways and Ramps).

1. Minimum sight distances (for horizontal and vertical curves) shall be as follows:

Design Speed Miles per Hour	*Non-Passing Sight Distance, Feet*	*Passing Sight Distance, Feet*	
		Desirable Minimum	*Absolute Minimum*
60	600	2,300	2,100
50	450	1,600	1,400
45	400	1,300	1,100
40	325	1,100	900
35	275	800	600
30	225	600	500
25	175	500	400
20	125	400	300

Highway Development

H. A. FLANAKIN

Mr. Flanakin has been Highway Engineer for the American Trucking Associations, Inc. since February, 1953. Between 1927 and 1936 he worked on highway construction and bridge design for the Louisiana Highway Department and for the American Bridge Company and others. In 1936, Mr. Flanakin, with three other engineers, set up the Traffic and Planning Division of the Louisiana Highway Department. Later, he was State Planning Engineer for Louisiana in charge of co-ordinating all parish and regional planning in the state. He holds a civil engineering degree and a certificate from the Bureau of Highway Traffic at Yale University. Mr. Flanakin was associate professor of engineering at Louisiana State University, acting director of its Engineering Experiment Station, and also served as a consulting engineer in city planning, traffic engineering, and public works administration. He is a member of the American Society of Civil Engineers, the Institute of Traffic Engineers, the Highway Research Board, and many other professional groups. He is a licensed Professional Engineer in the District of Columbia, Louisiana, and Texas.

THE ROAD is older than man. The first ones were located and used by animals seeking salt licks and watering places. There are persons today who doubt that man, with all his science, is really a better locating engineer than the cow.

These bovine creatures found the least energy-consuming ways to lift themselves over hills and down slopes to green pastures and water. The path chosen was always well drained. The foundations and surfacing were of sufficient strength to insure free and uninterrupted passage in summer, winter, fall and spring.

Every generation has been proud of its fine modern roads—especially the public servants who provided them.

Abraham found a road of some sort when he started and ended his travels.

Joseph was taken over a road into Egypt by a group of traders. And when he got to Egypt he found a well developed road system surfaced with asphaltic concrete.

Solomon developed roads throughout the world of his time. It

has been estimated that, based on current dollars, his personal income from trade along the roads amounted to some $20 millions a year.

Hannibal elected to invade Rome from the north. This decision necessitated building roads across the Alps to move his elephants and other war equipment.

Julius Caesar was far more proud of his role as a road engineer than as a militarist. One has but to remember his accounts of the Gallic Wars to appreciate this. Historians are agreed that the road system of Rome—developed as arteries of commerce—brought about advancement of that great nation.

One reason the Dark Ages were dark was that there was little social intercourse. Travel was virtually stopped because the fine Roman roads were neither expanded nor maintained.

Development in this country has been directly proportioned to road improvement but of a higher order than a geometric progression. We have the best system of roads, and perhaps the best roads, of any nation on earth. Yet today they are inadequate for traffic needs. This prompts us to ask two questions: How have we designed our roads in the past; and what design do we need for tomorrow's traffic?

Certainly not a great deal can be gained by looking backward too much. However, it is advisable to review what has been done to avoid mistakes of the past. It is well to ask how long have we been designing roads for automobiles.

It is not precisely known when man hitched a horse to a wheeled vehicle. Earliest biblical mention of horses and chariots is in Genesis. It is generally assumed that it was 6,000 years before Christ. The automobile made its appearance about the end of the nineteenth century. Thus for over three hundred generations man could travel no faster than a horse could trot—from three and a half to five miles an hour. Vehicles carrying goods moved at the speed of the ox or the mule.

For this type of traffic there was little need for wide rights-of-way and for multi-lane divided highways. The centrifugal force of vehicles rounding curves was rarely of such magnitude as to overcome friction between the wagon wheel or the horses' hoofs and the road. The horse didn't mind if the road turned here or there. If the grades were too steep he simply balked until additional horsepower was added or he became rested.

Stopping distances were not so great as to preclude approaching vehicles' coming to a complete stop or turning out of each other's paths to prevent accidents. It was deemed useless to build more than one road or lane on a route. If a fill or bridge were needed to put the road above high water, turn-outs could permit one vehicle to pull off the road to let others by. As late as 1924 the police jury of a Louisiana Parish told us it was a waste of money to build a bridge wide enough to pass two vehicles at one time. "Why, everyone knows that all vehicles must come to a complete stop before crossing a bridge or a railroad track."

The first textbook on highway engineering carried an admonition for the student to remember: "Do not design the pavement so rigid as to cause damage to the horses' feet."

Early Road-building Principles

The idea of one-lane roads prevailed among early road engineers. When the railways replaced roads, their engineers and builders were largely men who had been building roads. One-lane roads could serve two-way traffic because speed and volume were low. Rail traffic operated under rigid schedules: hence one lane could serve traffic, with sidings at stations where trains could pass. It was only in highly congested areas that more than one set of tracks was deemed necessary for rail traffic.

As railroad building waned and highways became more in demand, railroad engineers moved once more into the road-building field. This is not to say that these engineers were incompetent, nor to imply that they were lacking in vision. It cannot be gainsaid, however, that the inertia of nearly 8,000 years of practice is a strong force. Habits formed and continued down through three hundred generations are difficult to overcome.

Possibly prejudiced, the author believes traffic engineering—a generation old and still uninhibited—may prove to be the charged particle that will explode the old heavy atom, inertia. New ideas have already been separated. Radiation from these new ideas will undoubtedly generate other and better ones. Perhaps this thought will be more acceptable when it is remembered that the traffic engineer came on the scene about the same time as the low pressure rubber

tire. This was the instrument that gave full effectiveness to the internal combustion engine. These resulted in vehicles which permit man to move himself and his goods all the way from origin to desired destination, and without transfer among vehicles.

The engineers who pioneered in road building looked far into the future and did something in their day to meet conditions of the future. A few would include:

John McAdam who put into words a natural law that no matter how the road is built, it is the natural soil which must carry all of the superimposed loads comprised of the parts of the road itself as well as the live loads on the road.

Thomas H. MacDonald early recognized the importance of designing a road to take into account the deleterious effects of natural forces on roads.

Squire Whipple gave us a rational solution to truss bridges.

Robert Stephenson watched bridges in England collapse from vibration set up by marching men and flocks of sheep. He also watched the first bridge to pass a train. He reported that steel rails bent upward in front of wheel loads of the locomotive. When the train had crossed, the bridge was near collapse. He studied how to build bridges to carry loads hauled by transport vehicles. He conceived what he called a "tube" which led to development of the through-truss and through-girder type of bridge.

John Roebling and James B. Eads were both men of vision. They built the Brooklyn and St. Louis Bridges. The two bridges were started about 1857. They are standing and carrying both rail and highway traffic today. These bridges were built to carry railroad trains across the East River and the Mississippi. Soon after automobile use became definitely established, the bridges were adapted for highway traffic as well as rail. Recently additional lanes have been added to both bridges to pass increasing highway traffic. It is amazing that neither Mr. Roebling nor Captain Eads had ever seen a Coopers E72 engine, nor a tractor-semi-trailer-full-trailer combination of mid-twentieth century, yet they had the foresight to build bridges which are "modern" and a hundred years old.

These are a few of the forward-looking engineers who set patterns to inspire succeeding engineers. There are men of equal vision today. But our subject here is road design now and for the future.

The next and all-important question is—"What designs will be required for tomorrow's roads?" For those who want to take the easy way out, the answer becomes another question—"What kind of traffic will there be?" Little imagination or training is needed to design the physical aspects when the designer knows exactly the dimensions, weight, and frequency of application of load.

Tomorrow's Roads and Vehicles

Prophets in recent years have surpassed Alfred Lord Tennyson in "Locksley Hall." These soothsayers describe the vehicles as well as the ways over which they will be operated. At least Tennyson left the design of the "argosies of costly bale filling our heavens with commerce" to the men who would build them. Others have argued that with atomic-powered submarines and ships as well as airplanes, why not atomic engines for the passenger car?

Some of the prophets envision a new type of road vehicle for moving goods. Le Tourneau has built a road train bigger than anything conceived to date. The locomotive is mounted on rubber-tired wheels fourteen feet in diameter. The tires are so large and tire pressure is such that no more than five or six pounds per square inch is exerted on the roadway surface. The steering mechanism assures tracking as accurate as if steel rails were used for tracks. To be assured of adequate power, each wheel of each car has its own electric engine powered by direct current from a generator on the locomotive.

In addition to serving as power units for propulsion, these electric engines may be run in reverse, thereby providing positive braking in each wheel. These trains have been successfully operated cross-country where there are no roads. There has been no proposal to operate them over the roads since they far exceed legally established sizes and gross vehicle weights found in the several states.

As to direct use of nuclear energy, eminent physicists say "not in the foreseeable future." It is still heat generated from fission converted into steam that is used to generate the electricity we use. The shielding alone is so massive as to make a vehicle of the order of a million pounds gross weight about the smallest we can expect. One can imagine the consternation that would arise were such a land vehicle to be suggested.

Does it seem odd that moving vehicles weighing some 140 million pounds are supported on water with a unit weight of 62.4 and 64 pounds per cubic foot? Is it unusual that airplanes weighing a million pounds and more, are supported in air with a maximum density of around 0.09 pounds per cubic foot? These are everyday occurrences. Water-borne vehicles now move at 40 to 50 nautical miles per hour. The air-borne vehicles will and do move at ground speeds in excess of the speed of sound. What of vehicles on earth having a density of 100 to 120 pounds per cubic foot?

Recently there has been discussion of separate roads or at least especially built lanes for passenger-carrying vehicles and for those transporting goods. One prophet[1] says there will be a "limited mileage of high volume routes connecting population centers . . . the system totaling perhaps 100,000 miles. . . . Parts of the network will be used exclusively by passenger cars with adjacent facilities for commercial vehicles."

The idea seems to be that we will have two kinds of highway transport: Expressways for the "over the road" vehicles hauling long distance; local service roads for pick-up and delivery service. It is difficult to reconcile this with earlier concepts: "Highway transportation provides door-to-door personal transportation and door-to-door delivery of goods and services without limitations set by terminal requirements of other transportation methods."

The flexibility of highway transport is what affords it the popularity it has gained today. The fact that a sixty-thousand-pound "line-haul vehicle" operating from Boston to Los Angeles can pull up to a front door and deliver a water heater, picked up at a warehouse in Philadelphia, and be on its way with no loss in schedule time between termini, is the miracle of highway transportation. The quick turnover of inventory afforded by "warehouses on rubber tires" cannot be effected by any other form of transport.

Any attempts to confine goods-hauling vehicles to specific routes or streets would destroy the flexibility that has made highway transport symbolic of American methods. Whereas in the rigid forms of transport there must be fixed termini, in highway transport there can be as many terminals as there are trucks or even separate ship-

[1] J. P. Buckley, Chief Engineer of the Automotive Safety Foundation, "Highways of the Future," University of Michigan, Ann Arbor, Michigan, July 12, 1955.

ments on a given truck. Schedules are flexible too. Since every load-carrying vehicle has its own power plant, the time of departure is fixed only by accumulation of a full load. Here again there can be as many departures and arrivals as there are vehicles. If a shipment arrives at a truck terminal a few minutes after a truck has departed, it need not be held any longer than the time to load an additional truck. This is quite different from vehicles or trains of vehicles that must move out on fixed schedules.

Another argument advanced for separate lanes or roads for trucks and passenger cars is the time lost in climbing grades. A number of studies of this problem have been made by committees of the Highway Research Board. William E. Willey, Chief Engineer of the Arizona Highway Department, has given much time to the problem.[2] Mr. Willey found that strategically placed passing lanes can relieve all of the congestion caused by slow-moving vehicles. On Yornell Hill (a continuous grade of 6 percent for a distance of four miles) it was found that three pull-out lanes, each 1000 feet long, placed at properly selected sites, eliminated all of the congestion on this grade in a minimum of time and at nominal cost.

Mr. Willey presented his final paper at an annual meeting of the Western Association of State Highway Officials. To the inevitable question, "How did you assess the cost to the truck users?" Mr. Willey replied that a great deal of study had been given to cost responsibility. Time and distance surveys showed that actually truck time had not been improved by the three turn-out lanes. To avoid the contention that since travel time of passenger cars only had been improved and therefore they were the only beneficiaries, the Arizona Highway Department decided to pay for the improvement out of general highway funds.

A further argument of recent years has been that it costs much more to build roads for trucks than for passenger cars. Pavements must be much thicker. Grades must be less steep and curves more gentle.

This subject has already filled many books. A careful review of these treatises will reveal that most of the claims have been advanced by economists, highway administrators or engineers who have turned economists. For the most part the reports have been prepared to

2 Cf. HRB Bulletin 104, "Vehicle Climbing Lanes," National Academy of Sciences, 2101 Constitution Avenue, Washington 25, D.C., Publication 354, 1956.

convince legislators as to the fair share of highway costs which should be borne by passenger car owners and owners of trucks. Nearly all of these determinations of fair share have been based upon proportionate damage, which is a negative approach.

The Federal-Aid Highway Act of 1956 directed at least five studies having as objectives this and many other problems. The AASHO road test—a research project expected to cost more than $12 million, according to Commissioner Curtiss of the U. S. Bureau of Public Roads—will show what pavement structure is required to support specific axle loads applied with known frequency.

Safety Factors in Construction

This author believes that anyone who envisions highway transport with only passenger cars is visionary or misguided. It brings to mind a statement in the New Orleans Metropolitan Study some ten years ago to this effect, "Merchants in the golden triangles want crowds in their stores without congestion, they want people without vehicles. It is nice work if you can get it."

What type of electrical, gas, or water services would we have if there were separate systems for residential and commercial users? What indeed would they be like if these utilities were reserved for use by families only?

Another thought our road designers should keep in mind is adequate factors of structural safety. Often we become so economy-minded that we are apt to "design for a given load" rather than to build to minimum construction standards. Over the years this country has developed building codes that assure us when we enter a building it is safe to do so. Most of the time these minimum construction standards are fixed by some other requirement than live load. Early builders found that joists having a deflection of more than 1/360th of the span-length resulted in cracks in plastered ceilings.

The deflection of a beam varies inversely with the cube of the depth. The cube of eight is 512 while ten cubed is 1000. Thus, other things being equal, a 10-inch beam will deflect under load only about half as much as an 8-inch beam. Actually a beam four inches in depth will carry the live load normally found in a house. On the other hand four cubed is 64. What would happen to the plaster in a house with

4-inch beams for joists compared to one with 10-inch beams? The 2- by 10-inch standard timber beam is specified as the minimum flooring joist in most of our building codes.

Economists or load-conscious administrators might raise eyebrows at such practices. The engineer who is well versed in natural laws, unless directed otherwise, will accept such standards as a factor of safety. Acceptance of safety factors by men like Roebling, Eads, Cooper and others makes bridges endure for centuries and render services never dreamed of by their designers.

In designing the Mackinac Straits Bridge in Michigan, Dr. Steinman allowed a safety factor of twenty to resist ice loads against the piers. He has ten times the weight in his cable anchors that load computations indicate to be needed. The over-all safety factor is well above four for the bridge as a whole. This means the bridge should be structurally safe for over a thousand years. I doubt that anyone today would question Dr. Steinman's design of this or any other bridge.

Another argument frequently advanced is that of safety. "It is unsafe to operate trucks and passenger cars on the same roads." "Trucks are wider, and need wider lanes than passenger cars."

About three years ago, under leadership of Dr. Theodore W. Forbes, the National Research Council held a seminar on human factors in highway safety. Representatives of the police, traffic engineers, industrial psychologists, educational and medical professions, and the judiciary were invited to attend. There was free and open discussion on safety at this meeting. The refreshing note was the thesis laid down and adopted by the medical profession: "Man can be conditioned to survive in highway transport." It was said the reason man travels so fast in road and air transport is because he wants to. The best thing a professional man can do is to make it as easy and simple as possible for man to do the things he wants to.

The truck driver, like any other person whose income is dependent upon his ability to do a job properly, is and will be a better driver than the amateur operating a passenger car. The sooner the problem is resolved and the passenger car driver realizes that trucks will be on the road, that much sooner he will adjust his driving habits. In the meantime, the road designer can well afford to look toward incorporating more safety features into tomorrow's roads. These features are known to our traffic engineers.

As to the lane width needed for passenger cars or trucks, many studies have been made. The question was asked last spring at the General Motors Proving Ground near Phoenix, Arizona. The director said that even with professional drivers he found passenger cars weave a great deal more at high speeds than the heavier trucks. He also said he would recommend a 15-foot lane for passenger cars and a 12-foot lane for trucks.

It is worth while to mention the work of the automobile and truck manufacturers in developing safety. Safety features built into the newer passenger cars have been well advertised in many media. Since trucks are sold to a much smaller clientele, some of them may have been overlooked. It has been recognized that heavier trucks need greater stopping distances than passenger cars. By mutual agreement through committees of the Society of Automotive Engineers, practical stopping distances for four classes of vehicles have been adopted.

Better brakes have been developed. Positive emergency brakes have been designed which automatically take over in event of brake failure and bring the vehicle to a safe stop. Truck and trailer manufacturers are installing these improved brakes on all new models. All of the manufacturers are pooling their efforts and making the new brakes available for installation on old vehicles at a nominal cost to the owners.

The Society of Automotive Engineers and manufacturers have developed improved lighting systems, and mufflers that curb noise. These items are standard on new models. Like brakes, new mufflers and lights are being made available for installation on existing vehicles at nominal costs.

One school of thought developed about ten years ago concerns balancing highway transport between the road and the vehicle. The idea is based upon a relationship originated by Adam Smith many years ago. It has been stated that the cost of operating a vehicle decreases as the weight increases, up to a point when it becomes more economical to operate two smaller vehicles than one large one.

In like manner there is a basic cost of highways which is not influenced by vehicle weight. Beyond this basic road cost, the cost of the road increases with increase in vehicle weight; at some point the two cost curves cross. This point marks the optimum in vehicle and road development. This, of course, is another controversy resulting

from efforts to finance roads at public expense and to distribute costs equitably among the beneficiaries. This idea may result in deciding what type of roads will be built and letting this determine what the vehicles will be like.

A similar problem came up in air transport some years ago. A commission reported in 1952 to the President in a publication entitled, "The Airport and Its Neighbors." On the subject of airport runway design versus airplane design, the committee said:

"The question of whether fixed airport facilities should control future airplane design is highly controversial. To say that the average-capacity airport should be the limiting factor in airplane design is to place undesirable inhibitions on progress."

Nevertheless these factors are prominent in the objectives of the research projects now being carried out by the Highway Research Board, the U. S. Bureau of Public Roads, and state highway departments. Just what effect these findings will have on road design is problematical.

One of the features of the Federal Aid Act of 1956 is establishment of a highway trust fund and dedicating certain highway-user charges to this fund. This fund then provides money to be used in building the roads. Economists call this the "commercial" plan. At least the concept that road building is an ordinary function of government and supported by general taxes is now changed. Today highways are income producers the same as other public utilities. It is too soon to see how this idea will be accepted by public officials who have held highways as something to be furnished by government.

Finally it must be pointed out that design standards for the geometric and structural features have been adopted by the American Association of State Highway Officials and the U. S. Bureau of Public Roads. Some will be disappointed to know that there are no great deviations from current practice.

In discussing the situation as it applies to airport travel, Jennings Randolph said: ". . . highway and street connections between business district and airport will probably remain the major facility for travel from one to the other. . . . The only real solution is in building high-speed, limited-access expressways."[3]

[3] "Airport to Downtown Bottleneck," *Traffic Quarterly*, January, 1956, p. 160, Eno Foundation, Saugatuck, Conn.

In the final analysis it can be said that we know what to do. Really, it is a matter of getting on with the work rather than worrying too much over what our roads and traffic will look like in 1975 or 2057. The best we can hope for is that engineers do not get caught up in a maelstrom of political and economic wrangling. Certainly there is greater need for learning how to finance roads—as we have financed other American businesses—on the profit incentive basis, than for any bold departures from our geometric and structural design practices. The one ray of hope is that for every worth-while project wanted by the American public, the money always comes from the people who want it.

We should bear in mind that the American engineer, when left to his knowledge of natural law and its application, has given us essentials today which were rare luxuries yesterday.

Co-ordinated Traffic Planning

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THE city is a living and growing organism. The way it will grow and function is determined by the desires and interests of its inhabitants. It has parts that grow old, obsolete, and from time to time are discarded or replaced. It has new parts, added as the need arises. It is required to function with those features it inherited from the past; but its future depends on what is planned and what is done in the present.

Certain vital operations of the city—those which are not the business of any one individual but the business of all individuals—are entrusted to the municipal government. This organization is charged with the duty of making the city most closely resemble what its citizens desire it to be. To lead this organization are men who will set policy, elected to their positions by the residents and thus expected to express the desires of the inhabitants.

However, these men cannot be expected to know in every instance the exact means to achieve desired ends, nor the limitations and implications of every suggested course of action. So these officials are provided with assistants, specialists who know the standards of one particular function of the city. These men are charged with the actual duty of operating the city, guided by policy decisions.

The city traffic engineer's specialty is the task of getting the best possible operation out of the street system he has inherited—the basic transportation facility of the city. He must also constantly plan for improvements in that facility. The city planner guides the city in its growth, in assisting the pattern of residential, commercial

and industrial development to be smoothly functioning and compatible.

The redevelopment director must find those areas which need to be rehabilitated, or discarded and replaced, and must determine what the replacement shall be.

This organization would be fairly simple and easily operated if it were not for those factors which inevitably arise in human relations—differences of opinion and conflicts of interest. There is the problem of understanding among the inhabitants, the policy makers and the specialists, as to whether true desires have been communicated and whether the specialist fulfills those desires and needs insofar as possible.

What is perhaps a more serious problem stems from the conflict of interests between specialists wherein what one would do to fulfill his task would be contrary to what another would do. This is an area of great interest for it is apparent that conflicts of specialty will arise. They must be successfully compromised if programs are to be forwarded.

How often has the city planner seen traffic steadily grow and in fact be encouraged by actions of the traffic engineer on city streets which were planned to be quiet residential places? How often does the traffic engineer watch buildings being erected with inadequate parking space; watch strip commercial activity grow and destroy the operating efficiency of a badly needed artery? These things happen in many instances because one specialist made a decision it was his duty to make but had not consulted others because he was not required to do so.

Or, if consultation has been held, the decision is basically unilateral and for very human reasons has been bent in the same way. To further complicate matters, the municipal government is not the only one interested in the workings of a particular city. The state and Federal governments have their interest; they have their specialists.

Development Administrator Appointed

New Haven, Connecticut—population 165,000 and center of a metropolitan area of 350,000—has perhaps been no better, perhaps a little worse than many other cities in the matter of co-ordinating

these functions in past years. Its department heads were reasonable men who could consult with one another and when possible work out differences where interests overlapped.

It had administrations which could call the various specialists together for co-ordination of efforts; but it could also see an important member of an administration speak out in public hearing in opposition to creating a public agency which the public apparently wanted and the sponsors thought the administration supported. The basic structure of the organization makes it difficult to have a centralizing influence which could enable New Haven to say, this is our combined decision, and therefore, this is policy.

On January 1, 1954, the Honorable Richard C. Lee took office as Mayor of New Haven. He brought with him his interpretation of the needs and desires of the city's inhabitants. While there is no question that he considered the efficient operation of all departments as a very important duty, it is equally certain that he believed the departments charged primarily with developmental activities were those most in need of energizing and co-ordination.

Here he found a veritable welter of agencies concerned with development activities of various sorts and all equipped to varying degrees of efficiency: A city planning department under a competent director with many plans drawn, awaiting activation; a redevelopment agency with plans partially complete for redeveloping a most crucial central area; a planning consultant engaged in drawing an over-all master plan for guidance of the development of the entire city.

A parking authority, charged with the responsibility of creating offstreet spaces, had undertaken some moderate projects but without technical help, or means to undertake major projects. The traffic engineering function was unassigned, being handled only as a part of routine policy duty and with the attention of occasional consultants. A housing code had been adopted and was being enforced to the extent possible with the staff accorded it.

At the same time, the state highway department was actively planning a state-long expressway which would pass through New Haven and would greatly affect its future. The Federal government had available funds to assist in redevelopment activities if a workable program could be presented. These were the agencies which

must be brought together if movement was to be forward and consistent.

To accomplish the desired co-ordination there was created the post of development administrator. He would deal directly with heads of agencies involved in developmental work and at the same time remain in contact with the mayor. Insofar as the departments assigned to him for this co-ordinating effort were concerned, he would represent the mayor and be their spokesman to the mayor and others. He was not provided with a large staff which would require direct control of routine action duties, but instead, through the department heads assigned, would be able to call into play the combined efforts of all of their staffs. These staffs could be adjusted in size and scope as programs demanded.

The appointee has a background in law and public administration, but it is important to note that he is not a specialist in one of the areas of development but instead is qualified to program and administer the efforts of the specialists in these fields.

Initially assigned to work under this administrator were the redevelopment director and the city plan director, the city planning consultant and the director of the bureau of environmental sanitation. Before traffic engineering could be brought into the organization it was necessary that this function be assigned. Accordingly, a traffic improvement study for the entire city was immediately undertaken.

An outside firm was retained and the aid of the New Haven Chamber of Commerce enlisted to carry out details of study. A direct outgrowth of the study was the creation of the department of traffic and parking, assigned to the duties of traffic engineering and technical direction of the parking authority. The director of this new department was immediately placed into the co-ordinated group so that traffic and offstreet parking became a part of the planning program.

Still another step was taken to insure that this co-ordinated development activity would not become isolated from the community. A Citizens' Action Commission was organized to keep the community informed of the aims and programs of the developmental departments. The commission consists of a large body of public-spirited citizens divided into committees which confer and deliber-

ate on various problems of development. The commission's full-time executive director immediately became a working member of the co-ordinated group.

Advantages of Agency Co-ordination

To obtain the desired co-ordination under the development administrator, a plan of scheduled working conferences with required attendance by heads of the assigned agencies was adopted. Sessions are scheduled at regular intervals and the entire day devoted to them if necessary.

Prior to each session the secretary of the group prepares an agenda which includes all items previously selected for discussion or report and new items any of the agencies desire to add. During these sessions each point on the agenda is discussed in detail. Each agency has the opportunity to bring to the others' attention the relationship of its specialty to any of the plans or programs considered.

Out of each session grow positive assignments of further study and reporting. Agreements are arrived at for co-operative work on particular problems and joint reporting. Most importantly, the development administrator has made available to him all detail needed for his decisions in guiding the program. After each session a record of the discussions is distributed so that continuity is maintained throughout.

There are many advantages to this particular organizational arrangement:

1. Each agency retains its own identity; thus each has the size and kind of staff required to carry out its normal routine duties and to carry through the workload it assumes as a result of the sessions.

2. Each agency has the opportunity to have the problems of its specialty as related to the proposed program thoroughly discussed long before any decision is reached.

3. Each agency grows more aware of the needs and problems of the others, resulting in greater understanding and growing ease in arriving at compatible solutions.

4. Possible competitive attitudes or jurisdictional disagreements are replaced by a co-operative spirit of working together.

5. Each agency has the benefit of the experience and abilities of the others, rather than applying what limited knowledge it might have in areas more closely related to other specialties.

6. The delays encountered when agencies of governmental units must seek assistance or information from one another is entirely eliminated by virtue of the agreements arrived at.

7. All announcements of policies and programs and all official contact with other organizations and governmental units emanate through the development administrator after decision has been reached in the working sessions; other units are in no way confused by any conflicting communications or requests.

8. Most important—a co-ordinated program is followed and the work gets done.

New Haven's Accomplishments

The proof of the success of any organizational arrangement is accomplishment. The City of New Haven feels justified in pointing out what has been accomplished in less than three years under this co-ordinated approach.

At the outset certain undertakings were in various stages of programming. The state highway department had plans for its Connecticut Turnpike well along the way. The Turnpike would be a limited access highway traversing the highly developed industrial shoreline of Connecticut from New York through New Haven and then northeastward to the Rhode Island border.

While this highway is part of the primary highway system intended for connecting major movements between population centers, there can be no question that as it traverses the city it will serve the people of New Haven. Thus it is of vital interest to the city that its location and design features be the best obtainable for that local service. Some prior agreement had been achieved with the highway department, resulting in the location and configuration of the Waterside Park interchange, the major interchange for central city service. The unanswered question was how traffic to and from this interchange would connect with the center of the city.

Through studies of the co-ordination group and the state highway department, it was determined that an expressway connection

would be built by the state and eventually extended westward so that it will become another of the state's primary highways, Route 34. Thus, co-ordination of plans by the city and the highway department solved the city's plans and the highway department's problems in a compatible manner.

When the traffic engineering department was created and added to the co-ordinated group, further studies were made for this same route. It was possible for the city's group to study the relationship of this expressway system to the operation of the central district streets. As a result of these studies the final design of the Route 34 relocation was set.

While the final design was necessarily the work of the state highway department, it was essential that the city's needs be incorporated. At the same time, design details of new city streets to serve the expressway were agreed upon.

Also at the outset of the program, considerable effort had been expended on studies of redevelopment areas. One had been selected for major emphasis but no further progress had been made. The co-ordinated group took this plan under serious study and brought it to final consummation. At this time property is being acquired and demolition begun in this first New Haven redevelopment area. Plans for this area involved closing several streets, some minor and some relatively important to the present traffic pattern. Under the co-ordinated program the traffic engineer had the opportunity to study the effect of these closings and to determine what the operation of the newly created street pattern would be to serve traffic adequately.

At the same time the traffic engineer was in a position to support planning aspects where street closings improved operational characteristics by eliminating poorly designed intersections and serious conflict points. Also, as the planners developed the proper re-use of the area, there was opportunity to make certain that sufficient off-street parking would be provided along with the new uses.

Under the co-ordinated program the parking authority was given the opportunity to forward its important purpose of increasing available parking space in the central business area. At the outset a basic flaw in the enabling legislation of the authority hindered its possibilities of financing proposed programs. With this fact known and understood by the co-ordinated group it was possible to muster

the interest and support which saw the needed remedy through the state legislature speedily and without conflict. Immediately the parking authority undertook its first major project and in 1955 constructed a mechanical parking garage and two parking lots in the heart of the retail area.

The terms of the authority's enabling legislation require that the city plan commission approve any site chosen by the authority for such facilities. With the co-ordinated group in action it was known when the site was chosen that it would be acceptable so the necessary approval was easily obtained.

At present, the parking authority continues to work toward additional facilities. In every instance the location and design of facilities are related to redevelopment plans, to changes in street pattern as a result of new construction, and to changes in the operational street pattern as it may come about.

The entire traffic engineering function is such that a continuing series of traffic improvements can be planned and carried out. At the same time the department of traffic and parking is carrying out its normal routine of street painting and marking, handling complaints and suggestions, and operating the parking authority's facilities, plans for improvement can be studied and related to the activities of the other co-ordinated agencies. Under this program extensive additions have to be made to the city's one-way streets. Major improvements in curb parking controls have been accomplished. Departmental plans for additional improvements such as street extensions and bridges are integrated with the plans of the city plan agency and the redevelopment agency for land use improvements related to these undertakings.

Three additional areas of the city have been placed under active planning for redevelopment or renewal. Each area contains problems of street and traffic improvement, from closing minor streets to widening of arteries and construction of expressways. For each area every one of the co-ordinated agencies has studies in progress related to its own specialty.

At every working session, results of studies to that point are discussed and agreements arrived at concerning findings and plans for continued work. As each study area approaches the action stage there is assurance that all of its essential needs will be ready for implementation.